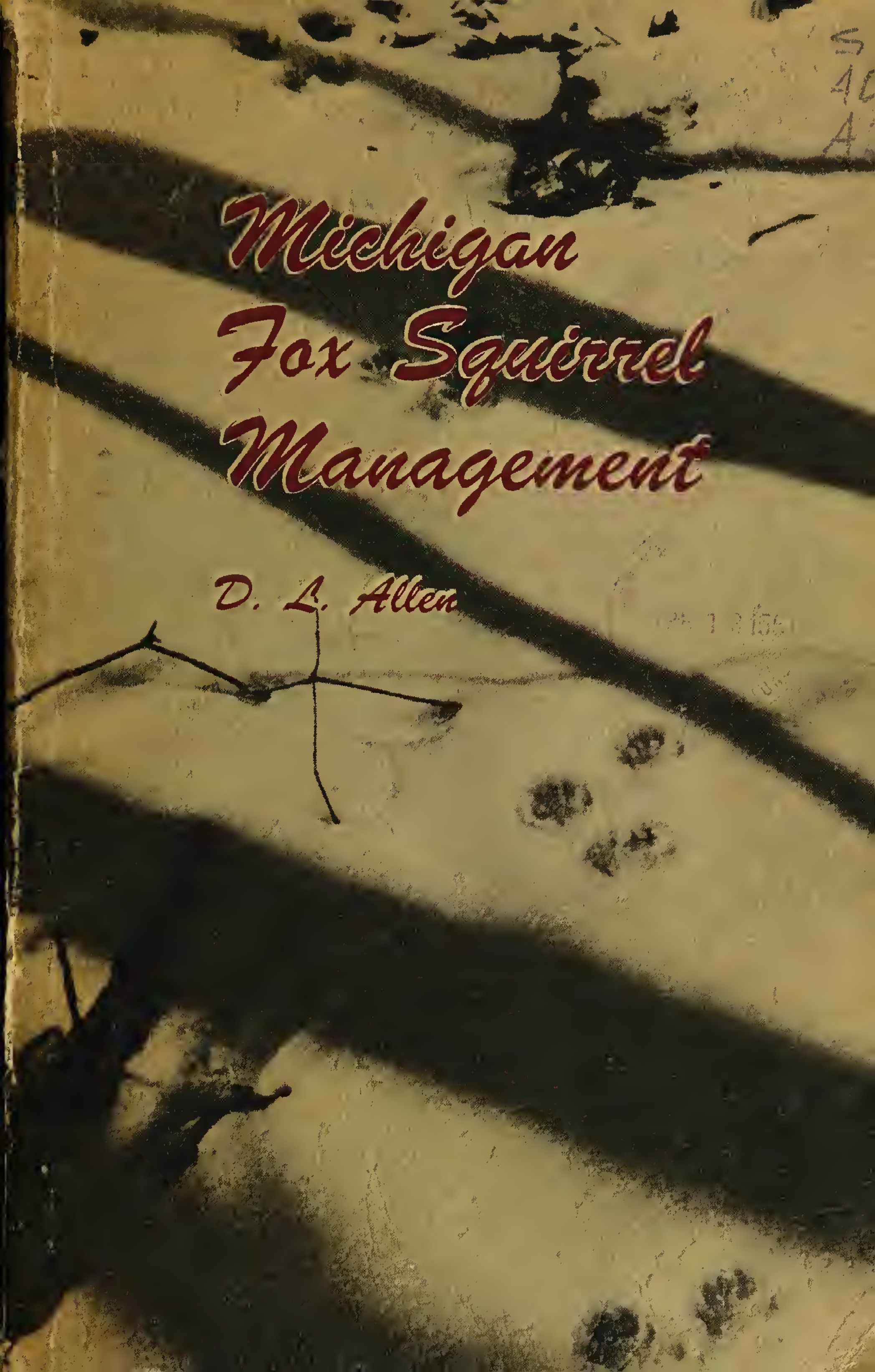

Michigan Fox Squirrel Management

D. L. Allen

With 212 illustrations, including photographs by the author and others and 28 drawings by Oscar Warbach.

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#K

FOREWORD

Game Division field studies are aimed at making Michigan's wildlife resources an increasing benefit to the public. The sportman's need for a yearly crop of game provides the most immediate goal; and this is proper, since it is his money which pays for regulation and management. But a broad view of the conservation picture must be maintained. Game species can be managed only as they fit into a complex pattern of plant and animal life. Various human interests also are inseparable. The farmer owns the land. The public own the wildlife. Hunters want to shoot. And many of the people interested in birds, animals, trees, and flowers utilize them as the indispensable setting for hiking, camping, picnicking, boating, riding, gathering nuts, and similar pursuits. Probably the truth is that these activities, upon which there is no closed season, represent the greatest value of all. Certainly they must be considered.

The fox squirrel, in particular, is held in high esteem by the non-hunting public. Many cities and towns have a numerous population of these animals living in shade trees and parks. No other game species is so often seen and furnishes so much enjoyment to the average city dweller. This general appreciation of squirrels assures widespread approval of any move to conserve and increase them, even aside from the fact that the fox squirrel ranks third in yield among Michigan game.

The division has carried on field investigations of the fox squirrel since 1935. Work of an intensive nature has been in progress for five years. There still are many unknowns, but enough has been learned to justify a summing up of progress and aims.

The present report is a detailed compilation of facts and findings which should be useful to anyone having need for an intimate knowledge of this animal. It is intended especially to meet the requirements of game technicians, conservationists, students, and individuals concerned with managing fox squirrels on a particular tract of land. Described here are measures which to date appear practicable for the private landowner and the program of improvements being carried out by the state on public-owned game areas. It is evident that along these lines lie the best opportunities for maintaining Michigan's squirrel range in a highly productive condition.

H. D. Ruhl
In charge, Game Division.

The western fox squirrel, *Sciurus niger rufiventer* (Geoffroy)

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Introduction

The word "management" will be much used in these pages. Here it means the regulation and utilization of wildlife. Good public management should be directed toward obtaining the greatest good for the greatest number of people. That is what we wish to do with the fox squirrel.

One hundred years ago there was a squirrel problem, but it was the reverse of what it is now. The pioneer farmer who cleared a forty in the wilderness and planted it to corn was hard pressed to prevent gray and black squirrels, with which the surrounding woods abounded, from harvesting his crop for him. In early days eradication was the chief concern throughout the forested midwest, and community hunts and bounties were much in vogue. In the state of Ohio, county taxes were for a time payable in squirrel scalps (86).

Human populations have increased, and the squirrel-producing forests have been reduced. Now the main problem is to see that hunting-season crops of fox squirrels keep pace with the requirements of steadily expanding numbers of sportsmen who furnish funds for this purpose.

Some Fundamental Principles

The biologist's conception of animal populations and the forces which control them is here set forth with no apologies. In 1921, with the establishment of a non-partisan Conservation Commission, Michigan sportsmen decided that henceforth management of the public's wildlife was to be scientific rather than political. The idea has grown with the years and needs no defense or elaboration here.

Fluctuations in animal numbers

The only thing stable about animal numbers is the consistency with which they change. In the "green" half of our year things are growing, breeding, producing. The rest of the time they are consuming and dwindling. With the production of the last litter of summer young, animals reach their yearly maximum in numbers. Those numbers then decline until the first of next year's young are born. This might be called the yearly "turn-over."

The pioneer farmer was hard pressed to prevent gray and black squirrels from harvesting his crops.

Fluctuations in animal populations which seem to occur with regularity over periods of years are referred to as "cycles." There is some evidence that a tide of small rodents, the world over, ebbs and flows about every four years. The snowshoe hare and ruffed grouse evidently reach a peak of abundance about every decade. Periodically their numbers drop precipitately and then begin to build up again. There is growing evidence that disease is largely responsible for many of the so-called "cyclic" reductions of animal numbers. It is also possible that future studies may reveal a less regular phase in the ups and downs of certain animals than first indications implied. Increasing knowledge of animals suggests

that fluctuations in number are the rule rather than the exception. Hence, informed people no longer become greatly alarmed by them, even though causes and possibilities for control are little understood.

Capacity for expansion

Elephants are the slowest breeders among warm-blooded animals. Yet a famous naturalist once calculated that a single pair, beginning to breed at thirty years of age and continuing until a century old, could in 750 years produce a total of 19 million individuals. A female meadow mouse could in 12 months have a million descendants if every animal survived and produced the maximum number of offspring.

Under the same conditions it would take a pair of cottontails just 4 years to stock a township with one rabbit to the acre. The fox squirrel reproduces more slowly than any of our other small game animals except raccoons. Still, if a pregnant female were placed in Farmer Brown's woodlot and all of the ensuing squirrels lived during the next 7 years, they would constitute a happy family of some 2,500 animals.

What does this mean to the game program? It means that nature is well equipped to do the stocking. The game manager's function is to create conditions which will enable the young that are born to survive, grow up, and present themselves in the hunting season. The environment must provide those life necessities which will enable animals left over to live through the winter and produce a maximum number of offspring in the breeding season. The management job is to control conditions on the land and allow the animals themselves to do the rest.

The lid on the kettle

It has been noted that the potential breeding power of animals is tremendously high. It is an expansive force which, if unchecked, would cause any species to double and redouble until it occupied the universe. An animal population can be likened to a simmering kettle which keeps a constant pressure against the lid. Our pressure cooker will work peacefully so long as the weight on top of the lid is greater than the pressure within. The force holding down the lid is represented by the many mortality factors, such as disease, hunting, natural enemies, accidents, which are constantly cutting

down the "surplus" produced by breeding each year. If we ease up on the lid by eliminating or diminishing important factors, the kettle boils over. We then have an increase in the species, a "high" in the cycle, or perhaps even a "plague" of mice, grasshoppers, or whatever it happens to be. A shortage in the food supply, an epidemic of disease, or perhaps a flight of gulls over the wheat fields, puts a greater weight on the lid and the boiling-over ceases.

Thus animal populations contain an expansive force which is held within certain limits by the resistance of the environment in which they live. This environmental resistance is the lid on the kettle. It is what we will work with in regulating animal numbers. If more animals are wanted, the problem is to find out what factors are holding them in check and release the proper amount of pressure. If a species must be reduced, the most effective controlling factors must be determined and more weight put on the lid.

Carrying capacity

The maximum number of animals which a given unit of range can support at any given time will sometimes be referred to as its carrying capacity. The idea is familiar to any farmer. He knows that there is no use attempting to pasture even one cow on a sand blow. A corner of bottomland grown up to weeds and sedges may provide picking for one or two. Twenty acres of upland bluegrass means pasture for six or eight. But by breaking the sod of that field, adding lime and manure, and growing a lush stand of alfalfa and bromegrass the farmer can raise its carrying capacity to a dozen animals.

In the past many people have been too little disposed to think of game as a product of the soil, a land crop, yielded in terms of animals per acre. Yet game harvests can, and must, be dealt with in this way. How better can the quality of a given type of squirrel range be measured, say mature beech-maple woodland, than by determining how many animals it supports? And does anyone imagine that this number will be the same in an equal tract of soft maple? True, it has been emphasized that populations change, and numbers one year may not be the same the next. But one habitat may *average* many times the production of another, and that is the measuring stick. (The "habitat" of an animal is where it lives, its local environment.)

The Job of Management

Let us review a few points: We wish to maintain Michigan's squirrel range in a state of maximum productivity consistent with other uses of the land. In doing this we will take into consideration certain properties of animal populations. All species possess a breeding potential of almost unlimited possibilities, causing them to produce each year many more young than can possibly survive. The number that does survive depends upon various restricting factors which, taken together, can be called the environmental resistance. In some habitats this resistance is high, giving the range a low carrying capacity. In other territory the repressive effect of the environment is relatively low, permitting the land to support more animals per unit. By manipulating the factors which limit a species we can control the size of the population. Thus, improving the habitat raises the carrying capacity of the land, permits more of the yearly surplus to survive, and increases the hunting-season yield.

Is all this just a "highbrow" theory? The individual can answer that for himself. Is there actually anything in these principles that he did not already know? Probably very little. About all we have done is to take some abstract ideas and lay them end to end for easier usage. All that has been said is that there are good squirrel habitats and poor ones. And if enough were known about it we could surely change some poor range into better range and have more squirrels.

The Alternative

Habitat improvement as a method of increasing game may seem a long process and one fraught with many difficulties. Within certain limits that is true. There are many types of squirrel range, and in each the problem will be somewhat different. Much of the land is privately owned. Because of environmental factors over which at present there is no control, even creating the best of habitat will not guarantee *uniformly* high productivity. Further, it will take time to develop enough of Michigan's poor squirrel range to make a conspicuous difference in the state's annual kill. Is there no more direct approach to the results that are needed?

This discussion has dealt with natural production. The alternative is artificial production. A method that is being widely used on

birds by many states at an annual cost of hundreds of thousands of dollars deserves careful examination. Our objective is more squirrels, and any method that will accomplish this at a reasonable price is what we want.

There is only one report of fox squirrels being bred, even experimentally, in captivity. They can be born and reared, and they live contentedly in confinement, but they seldom breed. Even if a way can be found to circumvent the difficulties, what are the costs likely to be? Raccoons can be produced at a minimum of about five dollars each. A pheasant, turned out at 8 weeks of age by mass production methods, costs at least a dollar. Small game licenses at a dollar each will pay for little of this kind of management. Such stocking done before the hunting season can produce a few more animals to shoot—at the full purchase price. Stocking done after the season only replaces animals taken in hunting, and the same effect could be obtained by limiting the kill. Hence, turning out animals for "breeding stock" is no different from producing them to hunt. If they are held until spring, costs mount still higher. The results of artificial stocking projects in Michigan indicate strongly that the effect of liberating additional animals in an area already stocked is merely to add to the "surplus" that nature has already created in that particular year. The population invariably declines to the carrying capacity of the range.

We have no prejudice against artificial stocking where it will bring results—that is, in an area where the species is absent and the environment favorable. The method is being used at present in Michigan. As an example, wild-trapped sharptails are being liberated where lumbering operations, fires, and agriculture have created favorable areas of unoccupied range. The initial establishment of a species by this means is sound, because that reproductive power possessed by living things usually causes a few breeders soon to populate all adjacent favorable territory. While this is in progress much of the annual surplus does not die off but spreads into new range.

The conclusion must be, then, that there is no alternative to natural production. If more fox squirrels are wanted for hunting, they must be treated like any other crop. The game manager must do the equivalent of what the farmer does when he fertilizes the field, fits the ground, and cultivates his corn. It will not all be done in a year. That could not be expected. Man has been growing

wheat for six thousand years and he is still improving his methods. The mountain will not come to Mahomet, so Mahomet may as well get started.

Scope of This Book

This book deals with squirrels primarily as game. The state hunting kill is approximately 95 percent fox squirrel and 5 percent gray squirrel, and those are about the proportions in which the two are represented here. As the title implies, squirrel management in this state is almost entirely, for the present at least, fox squirrel management. Gray squirrels have not been intensively studied in Michigan, although available information on the species has been included where it aids understanding of historical changes or the present game situation.

The motive of the present work develops by the following steps: Part I—(1) An interpretation of historical changes. (2) An inventory of present range conditions and the squirrel harvest now being produced. Part II—(3) A study of the fox squirrel's habits and life requirements. (4) Formulation of what constitutes ideal conditions for this species. Part III—(5) Determination of how this ideal can best be approached on different land types. (6) A management program for this species in Michigan.

To many people the exact tie-up between wildlife research and practicable management is not always clear. Hence some effort has been made, in the case of the fox squirrel, to show how the one converts into the other. Relationships of the game program to such fundamental limitations as climate, soil, and economics are also stressed. The fox squirrel must take a proper place in the management of the land and its other products; and a good public understanding of such basic principles can profitably be made an objective in such reports as this. The publication of findings on the fox squirrel does not mean that studies have been completed. Work on the species will continue to be a part of a routine program of investigations. It will be obvious to the reader that many conclusions, tentatively drawn, are based upon insufficient data. Doubtless some of these will be revised or amended as more information becomes available.

Acknowledgments

The Conservation Department squirrel studies and the preparation of this report have been under the supervision of H. D. Ruhl, in charge of the Game Division, who foresaw the necessity for such work and provided state facilities for carrying it out.

The material included here has been drawn from many sources in addition to personal field research. Especially valuable have been unpublished reports by Robert D. Montgomery and various other field workers whose material is now in the Game Division files. These are referred to in the bibliography along with published works consulted. Coöperation of the Michigan United Conservation Clubs, through their executive secretary, Harry Gaines, is gratefully acknowledged. Questionnaires completed by their members and by Conservation Officers in every county of the state contributed to the picture of past and present statewide conditions. Valuable help and criticism on various parts of the report were obtained from J. O. Veatch, of the Michigan State College; W. H. Burt, S. A. Graham, and E. C. O'Roke of the University of Michigan; and G. W. Bradt, R. G. Hill, Donald Douglass, W. C. Gower, and others of the Game Division. I wish to thank Oscar Warbach for his skill and perseverance in the preparation of cartoons and drawings used in the text. Maps of squirrel ranges were drawn by H. D. McGinley. The bulk of the photographs are from the Game Division files. Some are from my own negatives. Those which I did not take have the name of the photographer affixed.

I am glad to acknowledge a special debt to the late P. S. Lovejoy, who did much toward making such studies as this possible in Michigan. His interest and helpful criticism were a valuable asset in the planning and preparation of the first-draft manuscript.

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Part One: What we have to work with and how it can be used

Chapter 1

HOW IT CAME ABOUT

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HOW IT CAME ABOUT

SOUTHERN MICHIGAN agriculture began about 1830. Although nobody knew it, our squirrel management program began then too. The earliest settlers were at that time homesteading the best land and speculating on the rest. Profound changes were wrought among the forests, swamps, and lakes that were to become Michigan. An understanding of those changes and their effects on animal populations should put us in a good position to predict what future changes, chance or deliberate, are likely to accomplish. To appreciate fully what the old settler found, one should glance back a few thousand years to learn how things got that way in the first place.

Climate and Michigan's Squirrel Range

The plant and animal communities of any region are determined primarily by climate and secondarily by soil and topography. Climates of the earth are not static, but are changing over long periods of time. And as they change, new communities of plants develop to fit new conditions. Soil is altered by the direct action of weather and by the vegetation growing upon it. Animal populations also respond to modifications in their environment and may increase or decrease, extend their ranges, or be wiped out. Changes in weather, soils, and plant and animal communities are endlessly interrelated. It is for convenience that they are here discussed separately.

The soil, from which all blessings flow

Thirty-five thousand odd years ago Michigan's climate took a turn for fair and warmer, and the mile-deep ice of the glacier began to melt from the southern peninsula. It left a jumbled jig-saw puzzle of soils ranging from fine sand to heavy clay, and a land surface varying from level stretches of former lake bottom to extensive systems of hilly moraines.

Michigan's climate is characterized by a rapid transition from south to north. The effect of this is shown in fig. 1, which is a map made by a soil scientist (102). Both the "podsol" soils of the north and the "brown forest soils" of the south were derived from similar parent materials. But deeper snows, a shorter growing season, and fewer soil organisms in the north have effected fundamental differences in weathering, mixing, leaching, and the deposition and decomposition of plant materials in the two regions. On this basis the state can be divided into two soil zones with a transition area between. It is the brown forest soil zone and transition area with which we will be most concerned in managing fox squirrels.

Forest succession

The forest pattern of a century ago was the result of changes which had been taking place since the weather warmed, ice flowed away through rivers, and the earth lay exposed to air and sunshine. The first plants to occupy the raw mineral debris in the wake of the glacier were those of the arctic tundra. As it became milder the climate progressively came to resemble present conditions in northern Labrador, southern Manitoba, and northern Michigan. This brought about a procession northward of the trees now common in those regions. The first tree species to become dominant were fir and spruce, doubtless accompanied by cedar, tamarack, birch, and aspen. These were followed by the pines and later by the broad-leaved trees, the oaks, maples, and all the rest (25, 83, 104).

It was not a steady change. There were fluctuations in climate which reversed the succession at times. There were two extended periods of little rainfall during which the forests declined in area and the grasses of the Illinois prairies spread east and north and became dominant on the more level uplands in parts of Indiana, Ohio, and southern Michigan. In its most recent trend the weather became moist, and the forests once more closed in on the prairies (42, 84, 114). This process was still going on when the white man intervened with axe, fire, and plow.

Soils and topography modified the northward advance of forests (41, 109). In some situations the succession never progressed beyond early stages. The flora of many bogs still contains species now common in the boreal forests of northern Canada. Michigan's

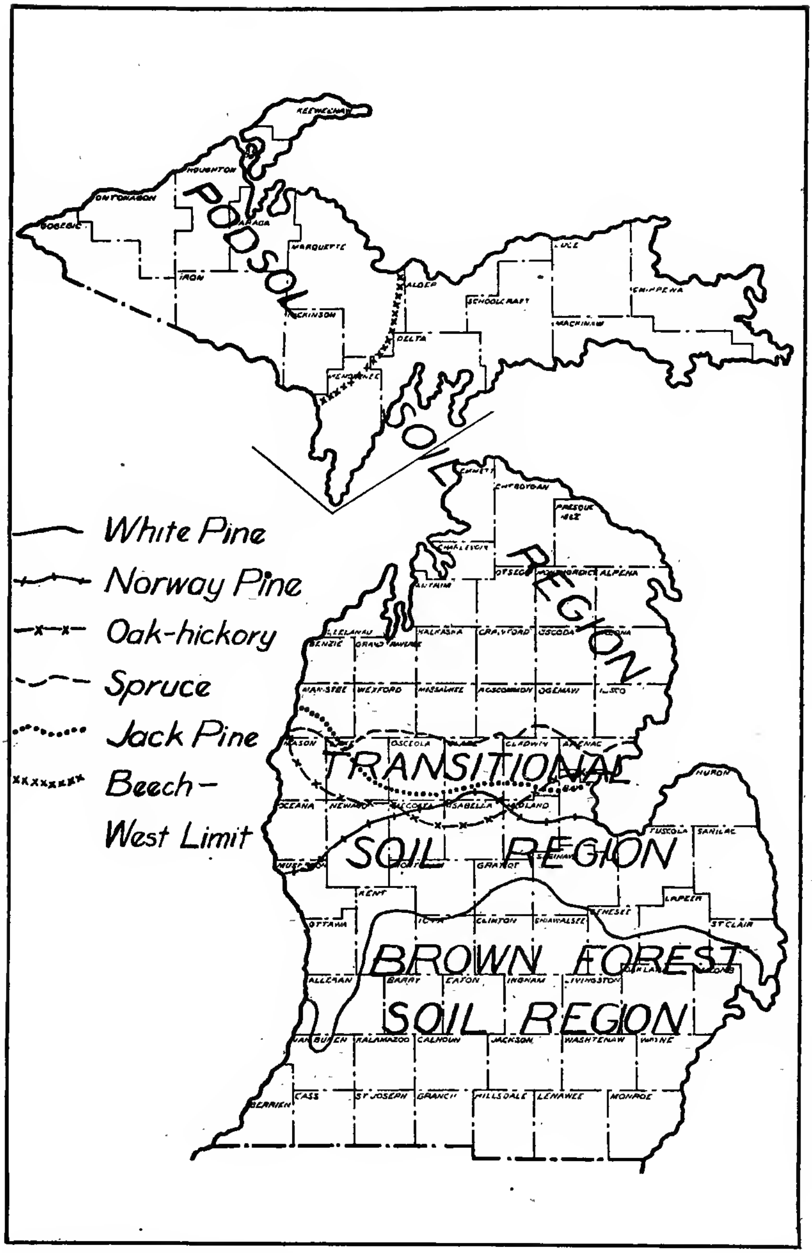

Fig. 1. Soil regions of the state and approximate distribution limits of certain forest types. From Veatch (102).

sand plains remained in pine and were only partially invaded by oaks. Oaks and hickories displaced pines on well-drained gravelly moraines and outwash soils, which were not suited to invasion by the hard maple and associated trees. These latter replaced other species on (usually loam and clay) soils of medium moisture content throughout the state. Lowland species advanced along river-bottoms and have remained there.

Many broad-leaved trees spread northward to a line that can be roughly drawn west across the state from Saginaw Bay. The transition zone for soils is also a transition zone for forests. North of this region the climate is not suitable for numerous hardwoods found in southern Michigan.

In nearly the whole state, land of neither too high nor too low moisture conditions came to be occupied by hard maple. In the south associated species usually are beech, basswood, white oak, red oak, tulip poplar, elm, walnut, ash, and others, depending upon drainage and sunlight. In the north, hemlock, beech, basswood, yellow birch, and red oak may share the better situations. There is some evidence that, as favorable moisture conditions and higher fertility were brought about by deposition of plant material and weathering of the surface layer, the hard maple - basswood - beech type was expanding. Some students of plant succession believe that eventually the oak-hickory covered hills would have been worn down, the lakes and swamp-forest lowlands would have been filled in, the soil would have become more favorable as to moisture and humus content, and all of southern Michigan would have been covered by a "climax" forest characterized principally by beech and hard maple.

Figure 2 is a map drawn by a forester (115). It gives a rough representation of the generalized forest types as they existed a century ago. It is evident that the climate which modified the soil from south to north delimited forests at the same time, and that vegetation zones coincide with soil zones. The point of emphasis is that the pioneers found merely a stage in a long series of changes of which the history has been pieced together from many sources. A strange story can be told by a sample of peat brought up by an auger from the depths of a bog. In it may be preserved the pollen of trees which were blooming there ten thousand years ago. These pollens can be identified and the composition of a bygone forest reconstructed.

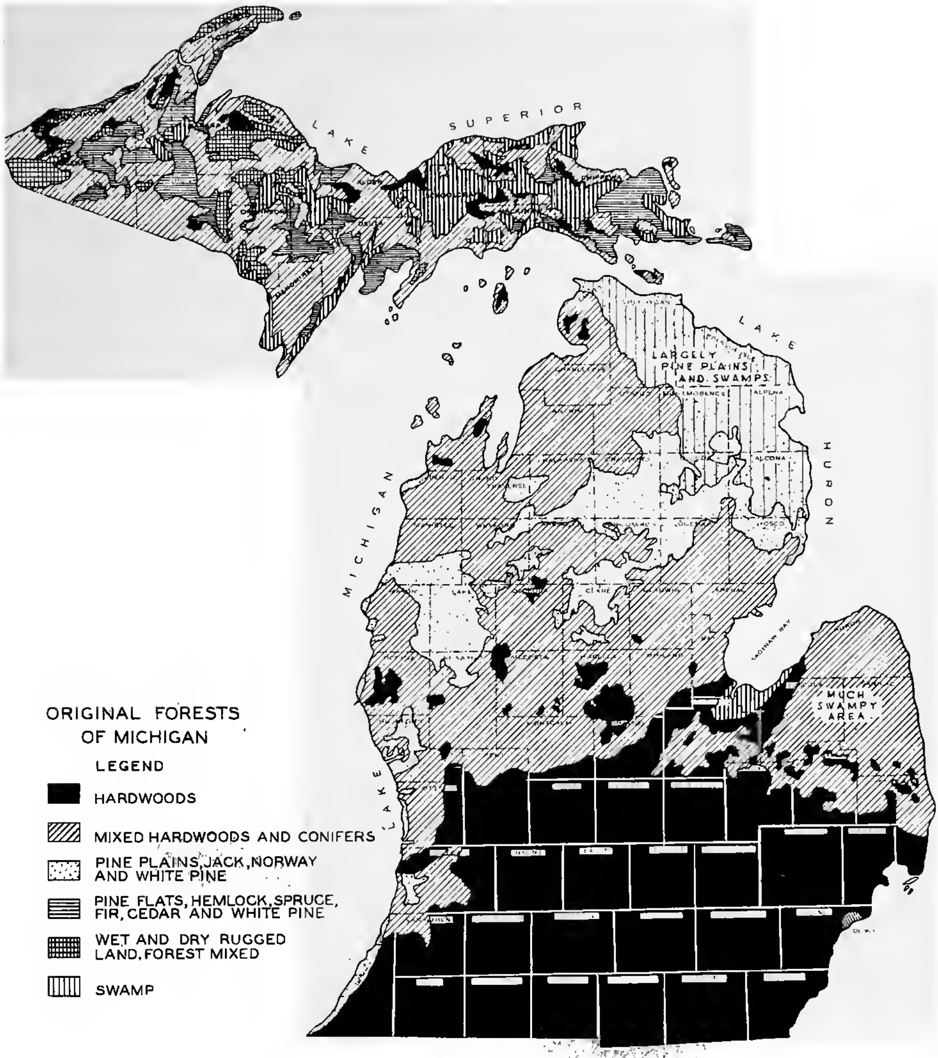

Fig. 2. Approximate distribution of major forest types at the time Michigan was settled. (By State Planning Commission, from Zon, 115.)

Animal life and the squirrel management zone

As has been shown, climatic differences have caused a natural division of the lower peninsula into two parts, each characterized by the nature of its soils and the plants which grow on them. Animals associated with the plants are also essentially different for the two regions. In recognition of this biologists have placed northern and southern Michigan in separate "biotic provinces." Describing and naming major plant and animal associations as biotic provinces and life zones is a convenient way of dealing with differences occurring on a geographic scale. The southern half of the lower peninsula belongs to the Carolinian, and the northern half has been assigned to the Canadian biotic province (30, 31). Thus the soil scientist, the forester, and the biologist agree on this division of Michigan.

It is not surprising to find that squirrels agree also. The brown forest soil—southern hardwood—Carolinian region is the state's best fox squirrel range, and it is here that management can be expected to yield satisfactory returns. The transition zone is also transition for the squirrels. Here the effects are felt of fewer mast trees, long cold winters, deep snow, and late frosts that often nip the blossoms and spoil the crop of seeds. Still farther north the hardwoods and pinelands are distinctly "marginal" fox squirrel territory, where the animals lead a precarious existence and fluctuate radically in numbers, depending upon a succession of favorable or unfavorable years. In this region range improvement efforts would be "bucking" the climate, and it is highly doubtful that, at any reasonable cost, they could be successful. About all the management that can be recommended for squirrels in northern forest lands is intensive utilization of the crop when the animals are plentiful.

Hence the program set forth here applies almost exclusively to the south half of the lower peninsula,[1] the region where big and fairly consistent yields of squirrels can be expected. We can not alter either climate or soil; but if these are favorable, local conditions, especially those depending upon the kinds and numbers of various trees, shrubs, etc., can in many cases be effectively regulated.

[1]This region will be referred to as "southern Michigan."

What the Pioneers Found

The pioneer farmers of a hundred years ago found extensive forests of southern hardwoods, but over much of the region not a fox squirrel.

The gray squirrel in primitive times

At the time of settlement there were gray squirrels in plenty. The gray phase was more common in some places, and the black phase predominated in others. It should be emphasized that the black squirrel of Michigan is not a separate species, but a color variation of the gray. Whenever we speak of the gray squirrel it is understood that both color phases are included.[2]

In primitive times, in the deep woodlands of Ohio, Indiana, and southern Michigan, gray squirrels evidently reached periodic abundance far greater than anything found in recent years. As an example, the late William B. Mershon of Saginaw told me of shooting 17 blacks and grays from one tree during a morning in about the year 1870. George W. Sears (82), in describing a trip from Saginaw Bay to Muskegon in 1842, stated that there was hardly an hour of daylight when these squirrels were not "too numerous to be counted."

In nearby states similar conditions prevailed. In 1856 Kennicott (64) wrote, "In northern Ohio, I have seen them in such numbers as to be truly astonishing. Dr. Hoy relates that he knew a hunter in that State to kill one hundred and sixty in a day, and that, too, when they were not unusually abundant in the locality. In parts of Michigan, Illinois, Southern Wisconsin, and Indiana, they are no less numerous."

W. L. Hahn (49) has quoted an early record from Indiana. "The historian of Bartholomew County gives an account of a great squirrel hunt which took place in that county in 1834. There was strong rivalry between Sand Creek and Wayne townships as to which had the best squirrel hunters. Finally it was agreed that each township should select fifty men to compete in a three days'

[2]The gray squirrel of southern Michigan is the northern gray squirrel *(Sciurus carolinensis leucotis)*. The subspecies found in the upper peninsula is the Minnesota gray squirrel *(Sciurus carolinensis hypophaeus)* which differs from the former chiefly in the gray and tawny fur of the belly. The *leucotis* subspecies has an entirely white belly, and in the northern portion of the southern peninsula there are animals which appear to be intermediate between the two. In both varieties, the black color phase (melanism) is common. Among gray squirrels ranging from southern Indiana southward the black phase is rare.

squirrel hunt, to be terminated by a great barbecue for which the losing side was to pay. The total number of squirrels killed is not recorded, but an idea of the destruction of the animals may be obtained from the statement that the individual championship was awarded for killing 900 squirrels in three days. The second largest was 783."

These large numbers were not uniformly maintained. In favorable areas in favorable years the animals built up rapidly to a point of overpopulation, and the mass migrations which occurred probably served to relieve such congestion. In describing this phenomenon Kennicott says, "I am not aware that any of these extensive migrations have been observed in Northern Illinois, but in the neighboring states of Wisconsin and Michigan, and in other localities where the species abounds, they not uncommonly occur. Immense numbers congregate in autumn, and move off together, continuing their progress in the same general direction, whatever it may be, not even turning aside for large streams." Quoting his friend, Dr. P. R. Hoy of Racine, Wisconsin, the author goes on, "He further says, that the migrations observed by him, in Southern Wisconsin, occurred when the mast was exceedingly abundant and the squirrels in excellent condition. Near Racine, they were observed passing southward in very large numbers for about two weeks, at the end of September and the beginning of October; and it was a month before all had passed." Dr. Hoy reported the Wisconsin migrations as coming at intervals of about five years, which may be an indication of the period over which gray squirrel populations usually fluctuated in that area. After such a mass exodus the animals would be comparatively scarce. "They rapidly increase in numbers, however, and, in a few years, are as abundant as ever."

An interesting record for Michigan has been given by Norman A. Wood (112). "J. Austin Scott witnessed a migration in the fall of 1840, when hundreds of gray and black squirrels crossed the Raisin River near Adrian. They came from the south and were so exhausted from swimming across the river that the boys killed many with clubs. He counted 30 in one small tree near the water's edge."

Where did they go? Nowhere in particular. In such large numbers squirrels were conspicuous, and they were killed off rapidly by their enemies—including man in settled areas. Paul Fountain (40) wrote that during such a migration in Michigan he heard of a party of a dozen guns who killed 20,000 squirrels in a week. On

SQUIRREL HUNT 1840

In the early days hardwood forests of southern Michigan teemed with gray and black squirrels. These animals, which are color phases of the same species, fluctuated in numbers but when abundant far exceeded anything known in this region at present. The cutting of the forest destroyed its habitat, and the gray squirrel largely disappeared from its former range in the southern half of the lower peninsula.

their marches many of the animals were drowned in streams and rivers which they did not hesitate to try to swim. Thus their numbers were dissipated and the overabundance relieved for another period. With the cutting of hardwood forests and the decline in squirrel numbers such migrations were much less frequent, but a few recent reports show that the animals still have the tendency (62, 85).

It is simple to explain it in this way—possibly too simple. Three-quarters of a century later we are not troubled by the same complexities which plague a first-hand investigator. But periodic migrations to relieve overpopulation have been observed among other animals (24, 80) and this is the logical explanation of the gray squirrel movements.

Early decline of the black squirrel

For some unknown reason, the proportion of black to gray squirrels conspicuously decreased after the coming of the white man to the midwest. Kennicott (64) stated that originally there were places in Illinois were the squirrels were all black, although this was rare. In 1869 Rufus Haymond (54) recorded that "The black squirrels were common—forming about one-third of the total number of squirrels in southeastern Indiana at the period of first settlement. Now they have completely disappeared." In accounting for this phenomenon, Hahn (49) considered hunting to be an important factor: "In other states, also, it has been found that the black squirrels are the first to disappear. This is no doubt due, in part, to the fact that they are more conspicuous and are therefore killed off more quickly. It is possible, also, that they are, in a way, abnormal and lack the vitality necessary to continue their kind under adverse circumstances. In southern Porter and northern Jasper Counties in 1905, the black or partially black squirrels were nearly as numerous as the gray."

Regardless of the cause, there is evidence that in Michigan, also, the black color phase of the gray squirrel was plentiful in the early days and disappeared more rapidly than the light phase after forest clearing and heavy (?) hunting began. Under the direction of Conservation Commissioner Harold Titus, the Michigan writers project of the Works Progress Administration collected kill records, estimates, and recollections on Michigan game species from older residents in every part of the state. Three reports from Eaton County deal with black, gray, and fox squirrels killed from 1866 to 1915. All show the trend in the yearly bag from black to gray and from gray to fox squirrels as the timber was cleared and the country became more settled. Probably some of these records are only estimates of the relative numbers of black, gray, and fox squirrels killed in some years, but their agreement is so striking that there

is no reason to doubt their general significance. In fig. 3 the kill reports of three long-time residents of Eaton County are lumped, and the percentages of black, gray, and fox squirrels in the total annual bag are plotted. These reports cover a total (presumably in part estimated) kill of 4,168 black, 1,357 gray, and 1,148 fox squirrels over periods of 38, 19, and 51 years respectively for the three hunters. From these records, it appears that in Eaton County black squirrels predominated in the days before extensive clearing operations. In the eighties, black squirrels were definitely on the decline, and the gray phase predominated. Fox squirrels were becoming numerous enough to figure conspicuously in the kill at this time. By the end of the century, black squirrels had practically disappeared in the county, and grays were also diminishing. There are statements in Appendix B from observers in the southern counties which bear out the trend shown in these records. In the northern half of the lower peninsula black squirrels fared better, and in some forested areas they at present far outnumber the grays.

This evident lesser ability of the black color phase to survive in the face of civilization was reflected in the Michigan game laws. From 1897 to 1911 all three squirrels were included in the regulations on open season. There was no bag limit. In 1911 the season on all squirrels was closed until 1919 when it was opened on fox squirrels. Gray squirrels were not again legally hunted until 1939, when a restricted area was opened to hunting of the gray, but not the black, phase. There has been no open season on black squirrels since 1911.

The fox squirrel in early Michigan

In contrast with the gray, the fox squirrel does not favor deep woodland. Originally it was a creature of the prairie edge. Its range was the transition zone between the eastern deciduous forests and the prairies. Oak-covered ridges, which represented the western outposts of forest in Illinois prairies, and "oak openings" which were the eastern vestiges of prairie in the woodlands of northern Indiana, Wisconsin, and southwestern Michigan, were its favorite habitat (64). Thus it is easy to understand why the fox squirrel

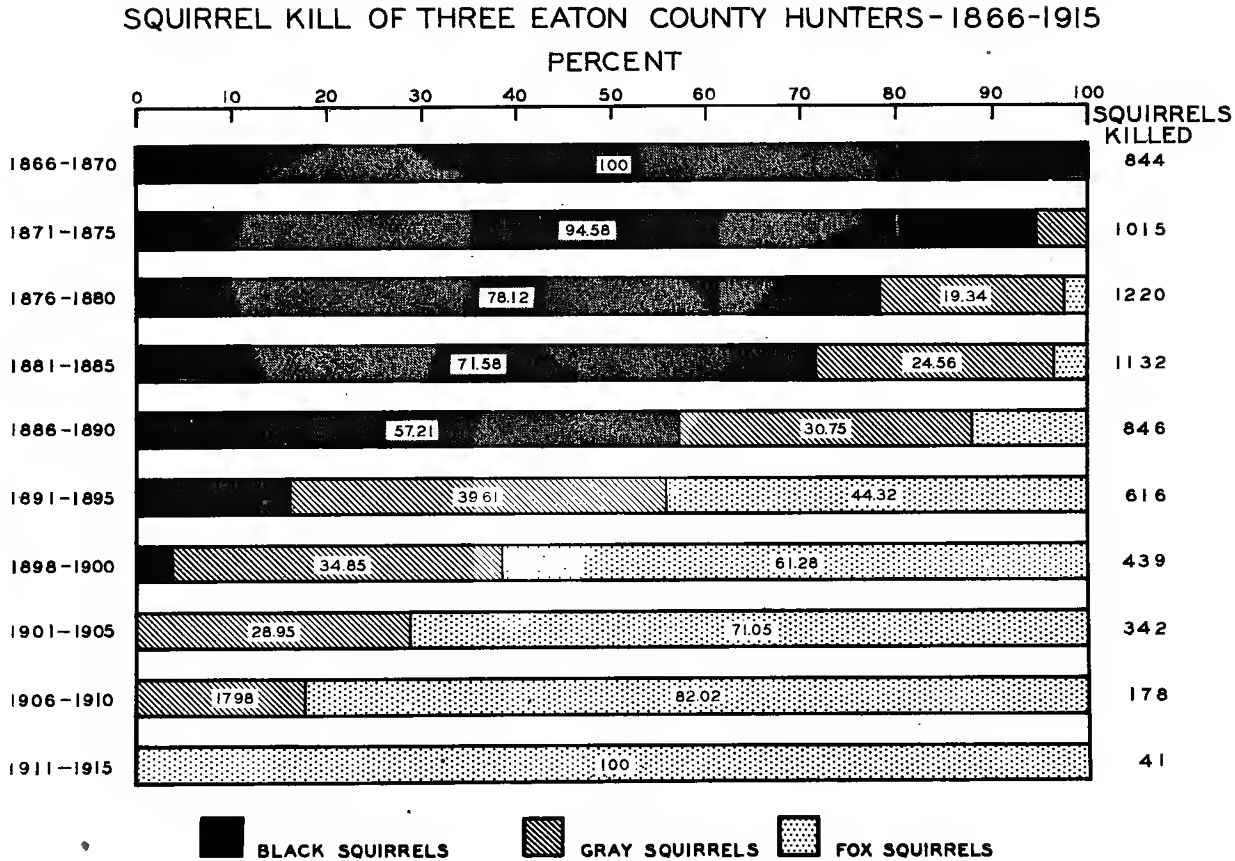

Fig. 3. In the midwestern gray squirrel population a century ago a high proportion of the animals were of the black phase. It was first noted in Indiana that the clearing of the forest and hunting resulted in a decrease in the proportion of black squirrels and an increase in gray-phase animals. Many reports indicate that the same thing took place in Michigan, and the squirrel kill of three Eaton County hunters, as given to the writers project of the Works Progress Administration, illustrates the trend. The hunters and the period for which they reported are as follows: Scott Boyer, 1866-1915; Savey Goodrich, 1875-1893; Benjamin Darwin, 1870-1907. There undoubtedly were some gray squirrels in the population, although in the first 5-year period Mr. Boyer did not report killing any in the locality where he hunted. By 1895 black squirrels were rapidly disappearing in southern Michigan, and the gray phase was also declining.

was uncommon or absent from most of southern Michigan where heavy forest cover predominated.

Only in the southwestern portion of the state, chiefly in Cass, St. Joseph, and Kalamazoo Counties, where there were areas of dry prairie (fig. 4) did this species find an environment to its liking. J. O. Veatch of Michigan State College (100) has located 39 of these prairie areas, varying in size from 80 acres to 25 square miles. Such openings were covered with sod and dotted with bur oaks. Today they are characterized by their deep, black, prairie loam, a lack of woodlots, and the ancient bur oaks, some of which have been left for pasture shade (fig. 5).

Kennicott (64) seems to be the only author who has mentioned the actual occurrence of fox squirrels in Michigan in primitive times. That thoroughly reliable naturalist refers to them as being present around the Michigan oak openings. Further evidence on the original range of the species has been obtained from Game Division squirrel questionnaires (Appendix A) which were sent to interested people in all parts of the state in 1941. Several observers quoted recollections of their grandfathers that fox squirrels were present in the prairie region when the land was first settled. Many older residents in this region attested that these animals had been there as long as they could remember.

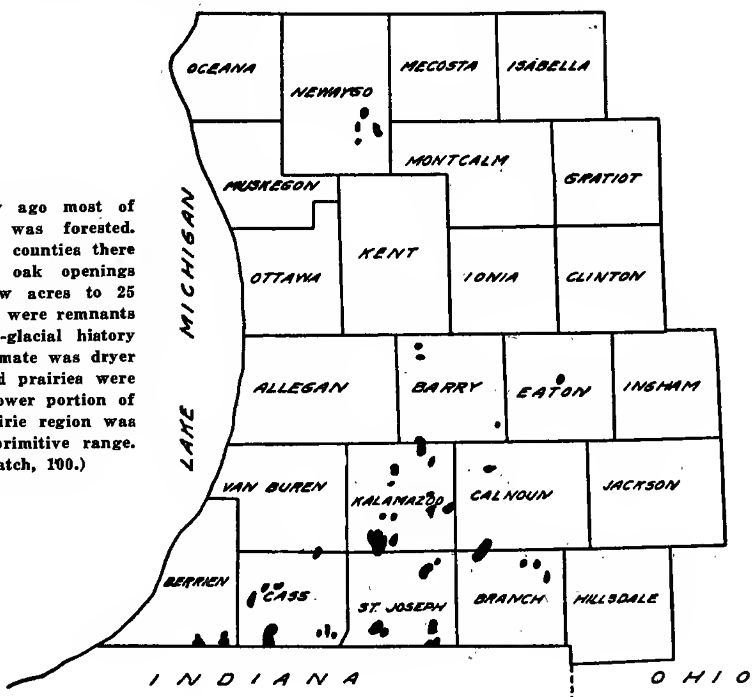

Fig. 4. A century ago most of southern Michigan was forested. In the southwestern counties there were prairies and oak openings varying from a few acres to 25 square miles. These were remnants of a stage in post-glacial history when Michigan's climate was dryer than at present and prairies were widespread in the lower portion of the state. The prairie region was the fox squirrel's primitive range. (Map from Veatch, 100.)

The prairies and oak openings were covered with grass and often dotted with bur oaks. On the margin between forest and open land the fox squirrel made its home before the coming of the white man.

Although its boundaries are somewhat hypothetical, the area dated "1840" in fig. 6 is a fair approximation of the area occupied by fox squirrels in this state a century ago. Doubtless these animals strayed out from the prairie region and became established where extensive clearings were maintained by the Indians.

What the Pioneers Did

If the settlers had had no other objective than to eliminate most of the gray squirrels from southern Michigan and to increase the range and numbers of the fox squirrels, they could have gone about it in no better way. The best method of doing away with any animal is to destroy its habitat; and a sure way to increase any species is to open up new and favorable range for it. By cutting dense forests the settlers eliminated the home of the gray squirrel. But in the new environment, farm woodlots interspersed with open fields, fox squirrels found conditions similar in many ways to their primitive habitat on the prairie margins. In less than thirty years they spread over the entire lower half of the southern peninsula.

Many wood cutters and farmers did not know what was happening. There were numerous reports that fox squirrels were

Fig. 5. As the prairies appear today. Many of the bur oaks still remain. Osage orange hedges are common in the fencerows.

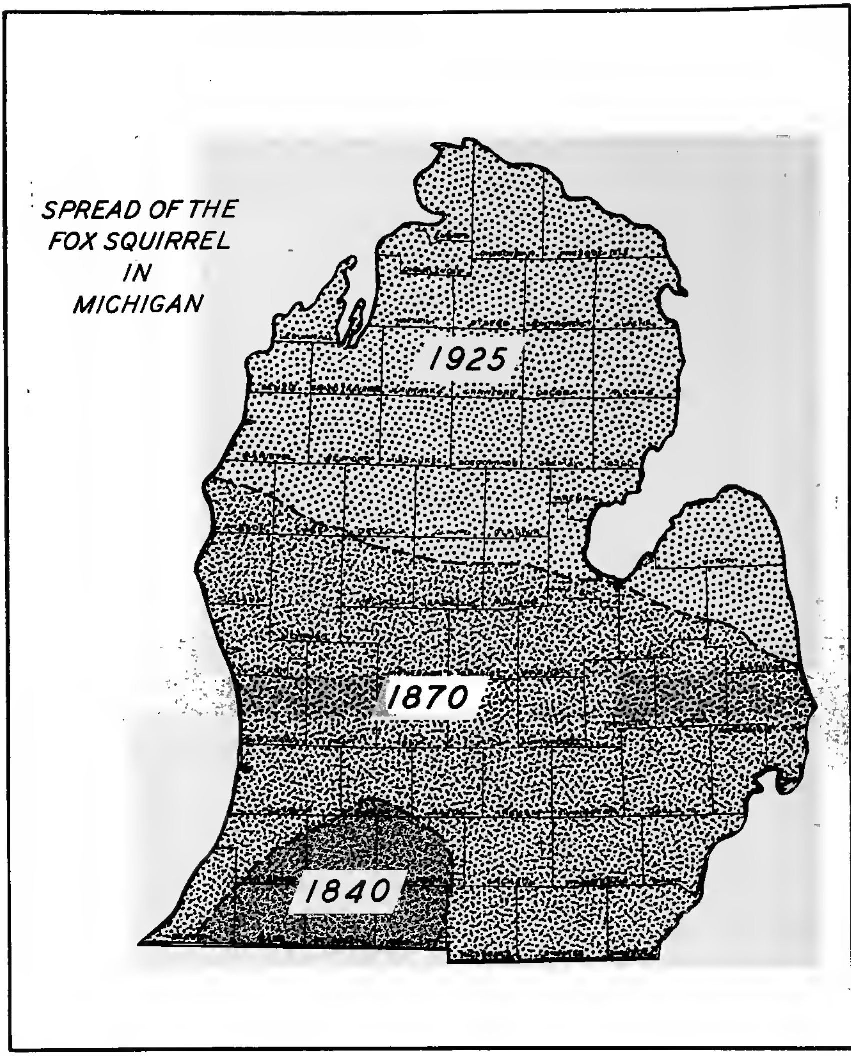

Fig. 6. As the forests were cleared, the fox squirrel spread northward and by 1870 occupied the lower half of the peninsula. In some localities in the northeastern counties the species did not appear until 1930, but there were a few in every county by 1925.

driving out the grays. When the woodland was cleared and the surface litter plowed into the rich topsoil, the early farmer was thinking only of his corn, wheat, and hay. But from what he accomplished there are lessons to be learned. Present squirrel management operations are on by no means so large a scale, but they

involve the same plants, animals, and forces. The same effective principle—habitat manipulation—can be used. And the effect of such manipulations in the past is the best guarantee of continued effectiveness in the future.

How the fox squirrel spread

There are a few published records which help to map and time the distribution of fox squirrels northward, and questionnaires have yielded additional information (Appendix B).

It appears that, as clearings were made in the region adjacent to the prairie openings, fox squirrels spread out from their native habitat and established themselves on the margins between open land and forest. According to reports, a few squirrels were seen in areas distant from the prairies a number of years before the species "arrived" in abundance. W. B. Mershon informed me that around Saginaw in the seventies, while the gray squirrel was still plentiful, an occasional fox squirrel would be found occupying outlying trees or clumps away from the dense timber. By 1875 the timber was being thinnned out rapidly (74), and as a result the gray and black squirrels (about 1 to 4 respectively in that region) were declining in numbers at the time the fox squirrel was increasing. T. L. Hankinson (110) reported that the fox squirrel was first seen around Lansing about 1860 and was "quite common" by 1886. H. A. Atkins verified this, stating that it appeared in Ingham County about 1863 and by 1883 was more common than the gray squirrel (113). W. J. Beal wrote that in Lenawee County there were no fox squirrels in the early days and that they came later from the south (13). In 1851 Bela Hubbard (60) recorded that at Springwells (Detroit) "The little red squirrel is the most abundant, but we are visited also by the larger gray-and-black species, and the fox squirrel." Norman A. Wood (112) observed the first fox squirrels in Lodi Township, Washtenaw County, about 1875, and they were rare for several years after that. The fact that the species had reached Saginaw by that year and had been observed by Hubbard at Detroit twenty years before, indicates that these animals spread rapidly where they found clearings to their liking, but that intervening territory was not occupied until agricultural operations had rendered it suitable.

AT HOME 1940

In woodlots throughout the agricultural region the fox squirrel found conditions similar in many respects to its former prairie-edge habitat. It extended its range, learned to eat corn, and now prospers on soil that a century ago nurtured dense forests and the gray squirrel.

Forest changes and the northern squirrels

The statements given in Appendix B show fairly well that fox squirrels had penetrated most of the southern hardwood region, that is, as far north as Montcalm, Gratiot, and Saginaw Counties, by 1870. Clearing of pines from the forest "transition zone" and the northern portion of the peninsula probably had little immediate effect on squirrels, as they were scarce in such habitat. Cutting of the northern hardwoods (mostly from 1890 to 1910) however, reduced the gray to a remnant in many localities where it had been

periodically abundant. During the first 20 years of this century forest fires held back the second-growth over large areas. But since that time regrowth has been widespread, and gray and black squirrels have shown an unmistakable tendency to "come back" with the forest. This is especially true where scrub oak has taken over original pine lands. As might be expected, fox squirrels were slower to invade this northern area. If reports are reliable, a few animals were seen on the western side of the state as far north as Leelanau County in the eighteen-nineties, and they were occasional in neighboring counties as early as 1900. But the species was seldom seen in Charlevoix, Cheboygan, and counties to the east until after 1920. A report from Alpena County dates their appearance there about 1925.

Several statements received from observers in the northern portion of the lower peninsula give a fairly good picture of the forest changes which induced corresponding changes in squirrel numbers. Conservation Officer Verne Dockham of Mio sent the following communication dealing with Oscoda County: "Mr. A. Hoy moved into the south half of Oscoda County in the summer of 1898. The bulk of the white and red pine had been lumbered off years before. The hardwood forests, except for one small area . . . were untouched. By 1905 several large companies were operating. The lumbering of the last large stand of virgin hardwood was finished . . . in the year 1913.

"The hardwood area was mainly in the south tier of townships. Between there and the Au Sable River were jackpine plains and two hardwood 'islands.' The jackpine plains were burned repeatedly, and the hardwood islands, after being lumbered, also were burned many times. By 1920 some headway was made in fire suppression, the last large fire occurring in 1925. After the fires were kept down scrub oaks became of sufficient size to bear acorns. The value of acorns is questionable, for the frequent failure of the crop reduces . . . the increase of squirrels resulting from seasons of good crops.

"Black and gray squirrels were abundant from 1895 until 1912 when the beechnut crop was good. . . . From then until the late twenties, however, they became very uncommon. Their greatest comeback was in 1934-35. The beech and oaks failed to bear fruit in 1935 and the winter was one of deep snow and low temperature. . . . Squirrels and their tracks were seen everywhere when the first snows came. As the winter advanced, they became fewer and

fewer. By spring it was a rare sight to see a track. They are still uncommon.

"The first fox squirrel seen was in 1921. They have been fairly common at times, but never abundant."

Mr. Dockham gives this further information, obtained from J. Winton, on the northern part of the County:

"White and red pine lumbering covered the period between the early 70's and the late 80's. The lumbering of the hardwood began in the 90's and continued to 1912. Black squirrels were plentiful until the close of the lumbering of the hardwoods. Grays were rare. I doubt that they ever exceeded two percent of the total of blacks and grays. There were times in the past when squirrels were far less common than usual.

"Fox squirrels were unknown until the early 20's. The first one seen was in 1922. The first forest fire tower was erected in the county in 1919. Fire control from that date permitted the growth of scrub oak. Fox squirrels increased until they became the most common of the large squirrels. The squirrel population, as in the south part of the county, rises and falls with the acorn crop."

Most reports from the northern counties indicate that over the entire region the sequence was much the same. Originally the gray squirrel, chiefly the black phase, was plentiful in the hardwoods during periods of favorable weather and mast production. The cutting of this timber destroyed their habitat and practically eliminated them in many places. Fire protection has allowed regrowth of the forest, both on better land and on the pine plains, and squirrels have shown a widespread increase. Judging from statements in the questionnaires, a few fox squirrels may have found their way north into this region previous to 1900. But cutting and fires probably eliminated most of them, along with the grays, until the early twenties.

It is possible also that some of the early reports of fox squirrels are cases of mistaken identity. It is not uncommon for a particularly tawny gray to be called a fox squirrel when both species are not at hand for comparison. Fox squirrels have sometimes been reported from the upper peninsula, but no specimen has been collected there. In recent years conservation officers and other observers have seen a few grays and an occasional black north of the Straits (Appendix B), but records of fox squirrels are rare.

The Conclusion

Thus, from a relatively few animals around the prairie openings of southwestern counties, the fox squirrel has spread to every part of the lower peninsula. The speed of its distribution was determined by the speed with which early farmers and lumbermen made conditions livable for it. Sometimes cutting went too far, as in areas which were clear cut and then burned. There the squirrel was destroyed. But with the resilience exhibited by most species which have survived the tribulations of the ages, it returns whenever the land becomes habitable. What man has done directly to the squirrels has been of little consequence. Hunting was unimportant in reducing them. Nor was any stocking necessary to increase them. Habitat control did it all.

Summary of Chapter One

On a basis of climate, soils, vegetation, and animal life, the lower peninsula of Michigan can be divided at about the middle into two natural life zones. The fox squirrel belongs in the southernmost of these, where such fundamental factors as climate and forest types are favorable. Since it is here that greatest returns can be expected, the management program will be constructed to fit the southern farming region. At the time of settlement, this part of the state was for the most part in deciduous forest occupied by gray squirrels. Fox squirrels were restricted to the vicinity of dry prairies in the extreme southwestern counties.

When the southern hardwood forest was broken up into farms, the new environment suited the fox squirrel, which spread out and became plentiful. Since its habitat was destroyed, the gray squirrel declined to a remnant.

There are now at least a few fox squirrels in every county of the lower peninsula, although in the northern half their numbers are very unstable owing to cold winters, deep snow, and the unreliability of acorn crops.

It is evident from what has taken place in the past that squirrel numbers respond directly to changes in the environment; and this is our assurance that managing the habitat is the most effective way to manage squirrels.

Chapter 2

MICHIGAN'S SQUIRREL RANGE

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Squirrel habitats and the trees composing them 48
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MICHIGAN'S SQUIRREL RANGE

IN SETTING up a business enterprise it is usually considered a sound approach to make an inventory of assets and liabilities, and then to figure out how they can best be used. This is such an inventory of Michigan's squirrel range. It deals with what remains of the original forests, what woodland types are represented, and present squirrel productivity in various parts of the state. An up-to-date map of southern Michigan woodlands, showing their extent and composition, would be a real asset in this work. Such a map does not exist, but to approximate it the work of the soil scientist can be used.

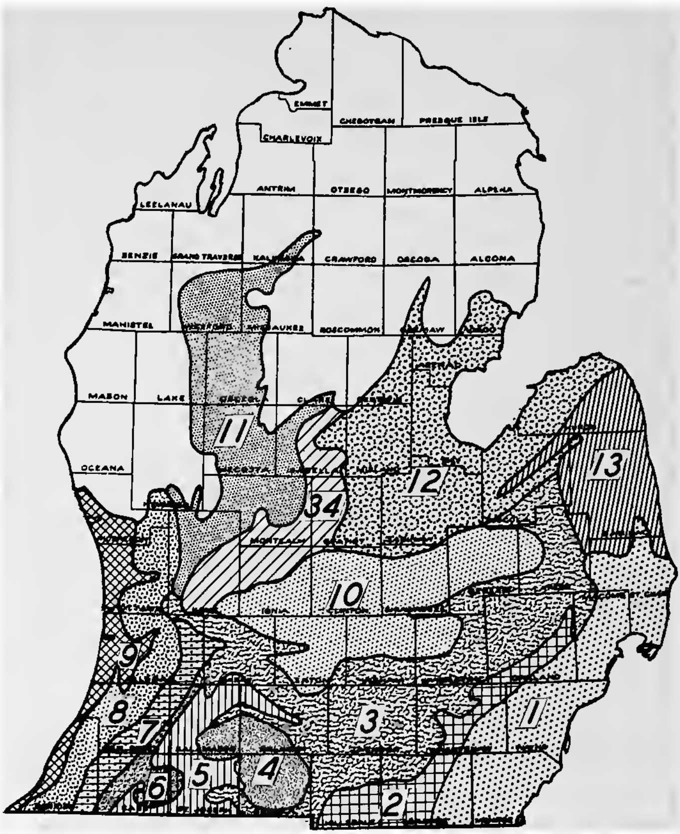
Natural Land Divisions and Existing Woodland

Land types[3] have been found to be relatively consistent in the kinds of trees they support. Hence, even after the woodlands have been cut, a fairly dependable map of the original forests can be made by mapping the soils and surface features of an area. In fig. 7 the lower peninsula is divided into its natural soil and topographical regions, and table 1 gives the classification of each with its generalized forest types. Both are taken from a map by J. O. Veatch (101) covering the entire state.

This provides a basic pattern of the tree associations which are to be expected in the southern portion of the lower peninsula. For the extent of woodlands in each county, the agricultural census report is our best source (98). It includes all but a very small percentage of the land. To give an idea of the woodlot pattern in a good agricultural area, Veatch and his students prepared a map of the uncleared land in Clinton County (unpublished). This is informative for our present purpose. (fig. 8).

Clinton County is centrally located; it is in the dairy and general farming area (57) and ranks among the leading four counties in the state from the standpoint of agricultural production. Most of this area supports hard maple - elm - beech woodlands, although the water-courses are bordered by the lowland type, and in the southeast corner of the county the woodlots are primarily oak and hickory.

[3]Which term includes soil texture, moisture conditions, topography, and to some extent climatic factors.



LEGEND

1- MONROE LOWLAND CLAY PLAINS
2- WASHTENAW HIGH CLAY LANDS
3- HILLSDALE-LAPEER SANDY HIGHLAND
4- BRANCH PLAINS
5- KALAMAZOO SANDY PLAINS
6- CASS SANDY HILL LAND
7- PAW PAW SANDY PLAINS
8- ALLEGAN CLAY UPLAND
9- LAKE MICHIGAN LOWLAND PLAIN
10-CLINTON ROLLING PLAINS
11-MECOSTA-WEXFORD SANDY HIGHLAND
12-SAGINAW LOWLAND PLAINS
13-SANILAC ROLLING CLAY PLAINS
34-ISABELLA RED CLAY LANDS

Fig. 7. Natural land divisions of southern Michigan (Adapted from Veatch, 101). A mapping of these regions shows the great variability of soils and topography over the state. Each division differs significantly from others in its forest and plant associations and also in the numbers and species of wildlife it can support. See table 1.

Clinton County is 365,440 acres in extent, and the 1935 census report showed that 93.2 percent of it was in farms. On these farms there were approximately 37,306 acres of woodland. The map illustrates that, even in a good farming district such as this, there are numerous well-distributed woodlots and hence ample opportunities for the management and production of game squirrels. Hunters' kill reports for 1939 showed a harvest of 13,989 fox squirrels in Clinton County, or slightly more than one per three acres of farm woodland. A management program would be worthwhile if it served only to maintain such yields as this.

Fig. 8. Map of uncleared land in Clinton County. (Courtesy J. O. Veatch, Michigan State College.)

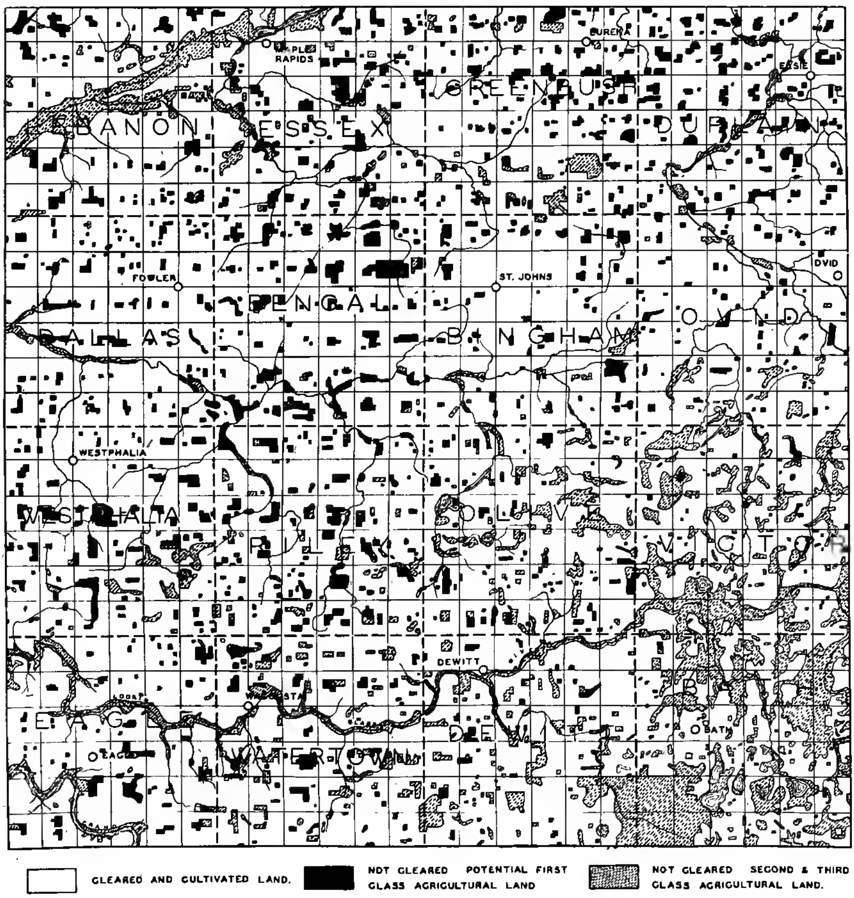


TABLE 1

Natural Land Divisions of Southern Michigan
(From Veatch, 101)

Name	*No. (Fig. 7)*	*Soil*	*Topography*	*Vegetation*
Monroe lowland clay plains	1	Dark-colored fertile loams underlain by clay.	Flat, level, in large part poorly drained; low, narrow sand and gravel ridges.	Hardwood forest; elm, soft maple, ash, hickory and swamp white oak; locally tulip, cottonwood, walnut, chestnut.
Washtenaw high clay land	2	Loam soils underlain by clay, medium to high fertility.	Rolling plains.	Hardwood forest; beech, maple and oak, hickory.
Hillsdale-Lapeer sandy highland	3	Light-colored sandy loams and sands; medium to low fertility; in part stony; large aggregate of muck.	Rolling and hilly highland with included level and pitted dry sand plains; lakes and swamps characteristic.	Hardwood forest; mainly oak, hickory; scattered white pine in northern part.
Branch plains	4	Complex of dark and light-colored loams; medium to high fertility; dry sandy loams.	Undulating plains of clay land, and level dry sand plains; lakes and swamp.	Hardwood forest; beech, maple, oak, hickory.
Kalamazoo sandy plains	5	Sandy loams and sands; medium to low fertility; large aggregate of muck.	Level plains, in part pitted with lakes; and locally choppy with steep slopes.	Hardwood forest; mainly oaks, hickory, partly prairie and oak openings.
Cass sandy hill land	6	Sandy loams and sands; medium fertility.	Hilly ridges inclosing dry sandy valleys; slopes generally smooth, but locally knob and basin topography.	Hardwood forest; oaks, hickory.
Paw Paw sandy plains	7	Sandy loams and sands; medium to low fertility.	Level plains, including a large aggregate of swamps and lakes.	Hardwood forest; oaks, hickory; oak openings and patches of prairie.

Allegan clay upland	8	Loams underlain by clay; medium to high fertility; sandy loams underlain by coarse, sandy drift.	Undulating to rolling clay plains; rolling to hilly sandy ridges; slopes generally moderate.	Hardwood forest; beech, maple, oaks, hickory.
Lake Michigan lowland plain	9	Complex of wet and dry sands; loams underlain by heavy clay; sands of low fertility; clays medium to high fertility.	Smooth land, low ridges and gentle swells; large aggregate of wet land; dunes along the lake shore.	Forest; oaks on the dryer sands; elm, soft maple, aspen, ash, oaks on the wetter sands; beech, maple, elm, basswood, hickory on the clays; pine abundant in the more northern areas.
Clinton rolling plains	10	Loams over compact clays; medium to high fertility; not excessively stony; large percentage muck.	Level to rolling clay plains with hilly and rolling ridges at broad intervals; swamps generally in long, shallow valleys.	Hardwood forest; sugar maple, beech, oaks, hickory.
Mecosta-Wexford sandy highland	11	Mainly deep sandy loams; locally sandy loams and loams underlain by red clay; mostly medium and low fertility.	Rolling and hilly, locally excessively steep; lakes and swamps comprise large aggregate acreage.	Hardwood forest; sugar maple, beech; mixed hardwoods, hemlock, and white pine; swamps of cedar, tamarack, fir and spruce.
Saginaw lowland plains	12	Complex of wet and dry sands and dark-colored clay and loams; heavy soils, high fertility; sands of low fertility.	Level land; low swells and low narrow sand ridges; large proportion poorly drained.	Forest; elm, ash, maple, basswood; white pine on sands and wet land.
Sanilac rolling clay plains	13	Light and dark-colored loams over clay; locally stony.	Level plains and gently rolling upland; less swamp, more rolling than 1 and 12.	Forest; elm, ash, soft maple, basswood, beech, maple, white pine.
Isabella red clay lands	34	Sandy loams and loams underlain by red clay; relatively medium to high productivity; less extensive acreage of sandy loams and sands of medium to low productivity.	Rolling clay plains, with ridges at broad intervals, which have rolling to hilly topography.	Forest; sugar maple, beech, elm, basswood, on the clay lands; mixed white pine and hardwoods on the hills.

Squirrel habitat in Michigan's agricultural region evidently is decreasing. In 1930 there were about 3,234,738 acres of woodland on Michigan farms. The 1940 census gave a total of 2,710,737 acres. These figures indicate that the past 10 years has seen a decline of about 16 percent in farm woodlots (fig. 8). The total loss has not been so great, because some submarginal land has gone out of agricultural use and is reverting to forest. It is true, however, that in the decade just past there has been a considerable decrease in woodland habitable for squirrels in southern Michigan.

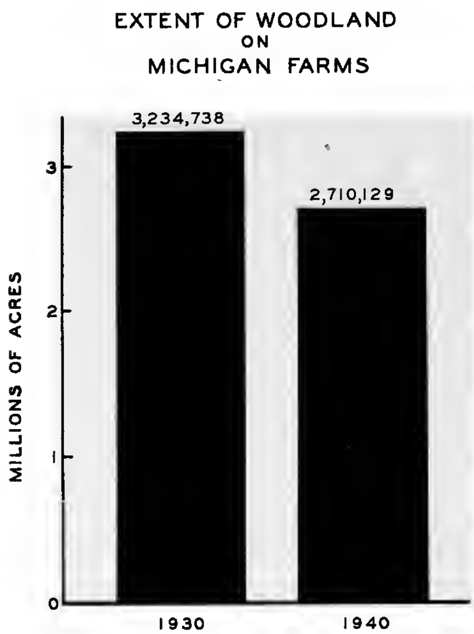


Fig. 9. Clearing operations have reduced Michigan's woodlot acreage in the past 10 years.

Squirrel Habitats and the Trees Composing Them

Some of the tree combinations occurring in the southern counties have been mentioned. It is hardly to be expected that all of these forest types would be equally good as squirrel habitat, or that they would require exactly the same handling to create good hunting. To some extent each major type must be considered a separate problem until its individual characteristics can be assayed in terms of squirrel requirements.

For squirrel management purposes woodlands in the south half of the lower peninsula can be divided into four groups: scrub oak, oak-hickory, beech-maple, and swamp forest. Of course many woodlands do not fit such a strict definition. But for present purposes a woods which contains a conspicuous amount of hard maple or beech will be referred to as beech-maple, even though it has a mixture of oaks, elm, or other species more common to another

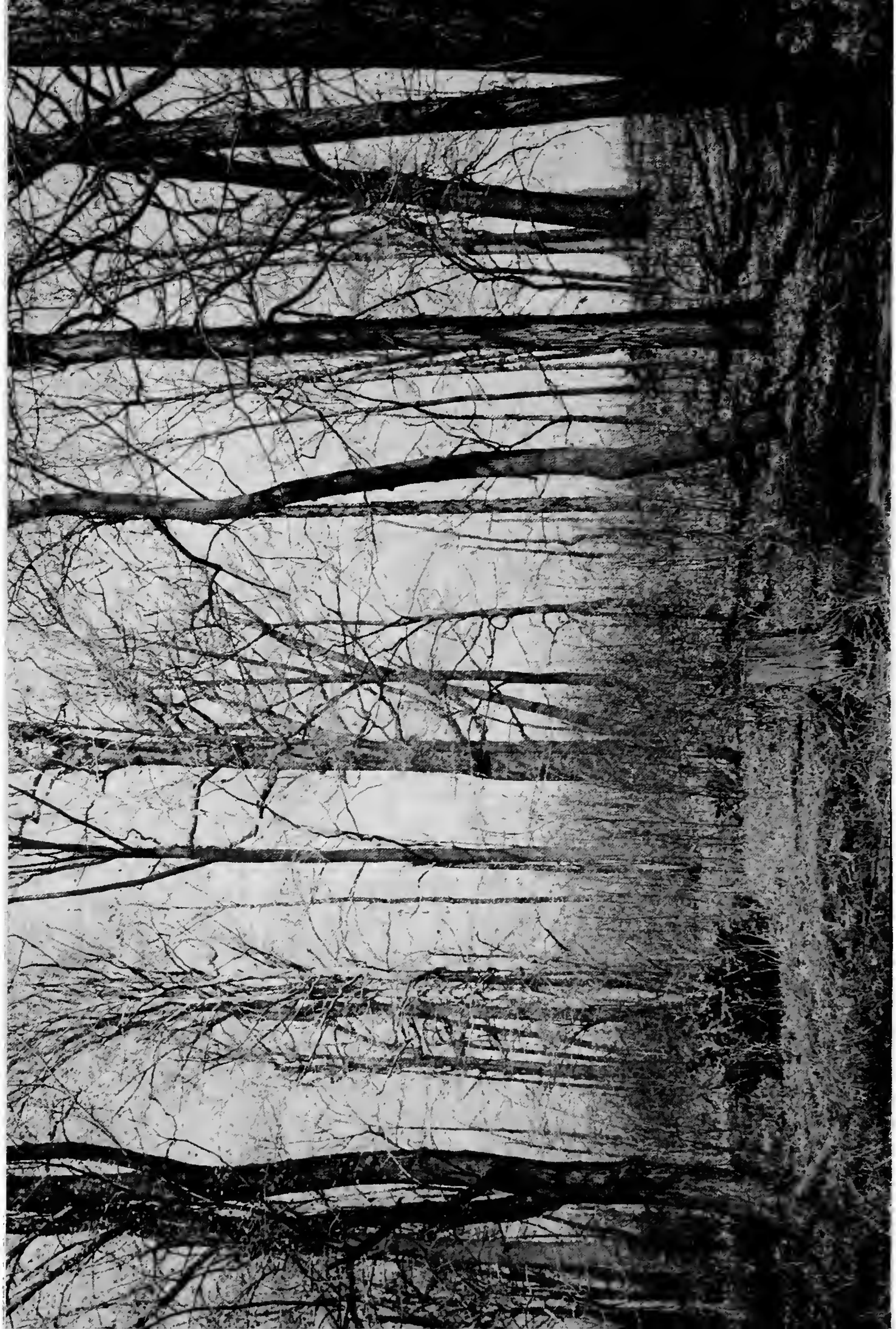
Fig. 10. This view of the Allegan County "oak grubs" is typical of the scrub oak woodland which now occupies the poorest sandy soil of the lower peninsula. Lumbering and fires eliminated most of the pines which formerly were on much of this land.

woodland association. It is obviously impossible to treat here all the existing borderline conditions, which the wildlife technician will need to deal with individually in the light of local circumstances.

Scrub oak

Deep light soils, such as Plainfield or Coloma Sand, representing the dryest upland situations, are usually occupied by black (or jack in some places) and white oaks.[4] Black oak is the first invader of openings, and white oak follows to form a mixed stand. It was pointed out in the discussion of forest succession that some of the scrub oak lands formerly supported a high percentage of pine, which was largely eliminated by logging and fires. The oaks form a well-defined range type which grades into swamp forest through a pin oak - swamp white oak phase where the water table is high, or into oak and hickory where the soil contains more clay.

[4]See Appendix E for the scientific names of trees mentioned in the text.



Oak-hickory

Forests of this type formerly covered southern Michigan moraines, till plains, and outwash soils. These situations represent well-drained conditions, but they comprise heavier gravel and clay soils not so dry as scrub oak lands. Oak-hickory predominates on rolling uplands and in the prairie region of the southwestern counties. The oaks are principally white, black, jack, and red, and the hickories are the small-fruited, shagbark, and bitternut. In places these woods are varied with red maple, hard maple, beech, aspen, cherry, slippery elm, and other trees. But the oaks and hickories are decidedly dominant over large areas and form our most important fox squirrel range.

Beech - hard maple

Forests characterized by beech, hard maple, and basswood developed where moisture conditions were intermediate between the oak-hickory uplands and poorly-drained swamplands. Woodlots of this type are found on heavy soils in some of the best agricultural lands of the state. They are typical of the most fertile uplands, but beech-maple may also occur on light soils where there is a heavier, moisture-retaining substratum or along the west side of the lower peninsula where unusually moist conditions are found in close proximity to the lake.

The originally extensive beech-maple woodlands of southern Michigan were varied with basswood, walnut, tulip poplar, red oak, white oak, and elm. Basswood, walnut, and tulip were the first to be cut out for lumber, and for that reason these are absent from many of the remaining woodlots. Beech-maple is the highest successional stage of woodlands in this state. It invades lowlands as they become filled in and dried out, and it moves into oak-hickory stands where soils evolve to a more mesophytic[5] condition through the deposition of plant material.

[5]A useful term meaning normal or intermediate in moisture conditions. The deposition of humus on sandy or gravelly forest soils enables them to hold more moisture and gradually builds up conditions suitable for beech and maple.

◀ Fig. 11. Oak-hickory woodland is found on most southern Michigan moraines, till plains, and gravelly outwash soils. It is the state's best fox squirrel habitat.

Fig. 12. In southern Michigan beech - hard maple woodland occupies soils of medium moisture content and usually of high fertility. It represents a higher stage in the succession of forest types than any other tree asso

Swamp forest

On the wet soils of river floodplains, stream bottoms, and old lake beds, swamp forest is the common woods type. American elm, soft maple, and black and white ash are the most typical trees. The maple is primarily silver maple in the Monroe lowlands region, but changes, as one goes northward, to red maple in the Saginaw Valley. Sycamore, swamp white oak, willow, butternut, basswood, and in dryer situations kingnut hickory, rock elm, slippery elm, beech, walnut, ironwood, hornbeam, pin oak, cottonwood, black maple, and tulip also occur in various localities as components of the lowland woods. Sometimes on former swamplands relatively pure stands of soft maple or elm are found. Mixed river-bottom woods is in Michigan an important type of fox squirrel range, since it occurs in most places as a narrow strip along watercourses and lies adjacent to farms and other woodland types. But pure stands of any tree, especially soft maple or elm, offer few comforts to a squirrel.

Using the Forest Types

It should be evident from the foregoing discussions that a given stand of timber did not just "happen." The various trees composing it are there in accordance with a well ordered sequence of changes. On upland areas in southern Michigan the usual post-glacial successional series would probably be pine, oak, oak-hickory, and beech-maple. After the glacial recession pines did not retain a widespread distribution because on all but the most unfavorable situations (dry sand) they were quickly invaded and displaced by oaks. Even where pine persisted the oaks probably would have predominated naturally, but man speeded the process by disposing of the conifers with axe and fire. But why is the oak type not more widely distributed? It undoubtedly was at one time, but as the climate warmed, and the moisture and humus content of the soil was built up in some places, large areas became oak-hickory woodland. And in the most level land and heavier soils oaks and hickories were forced to give way to beech, basswood, and hard maple, which, being tolerant of shade, were able to grow up beneath their rivals and finally shade them out. Under present climatic conditions that is probably the end of it.

Fig. 13. On river floodplains and old lake beds, swamp forest, the ash - soft maple - elm association, is the dominant woodland type.

Understanding these successional changes and their intermediate stages makes it possible to view a woodland in a new light. It is possible to predict what will grow if certain species are cut out. It can be foretold with reasonable accuracy what shrubs and trees will move in successive stages across a piece of open land if it is allowed to grow up to woodland. For it is quite evident that southern Michigan now has a "forest climate," and that any undisturbed opening on the upland will be invaded and occupied by trees. An understanding of succession makes it possible to determine the timber and game producing potential of a given area and to compare that with other values. The land and the forest change and mature together; and by knowing about it man can exploit the process to his advantage. The most significant phase of squirrel management will be the use of natural successional changes to produce a favorable environment. The practicability of nearly any such program can be judged by the extent to which it allows nature to do the work.

Summary of Chapter Two

The southern half of the lower peninsula is a complex pattern of land types differing in soil, topography, moisture conditions, and the plant and animal life they support.

The driest, lightest, and poorest sandy soils are usually occupied by scrub oak woodlands.

On moraines and till plains, well-drained clay and gravel soils typically support woodlots of oak and hickory.

Usually on heavier more level soils, where moisture conditions are intermediate between well-drained uplands and wet lowlands, the forest type is beech-maple. Under present climatic conditions this is the most advanced successional stage of southern Michigan woodlands.

River floodplains and other wet lowlands are ordinarily occupied by swamp forest in which ash, soft maple, and elm predominate.

These four woodland types are Michigan's principal fox squirrel habitats. They must be worked with in managing the species as game, and each can be expected to present a problem somewhat different from the other. The program is complicated by the fact that mixtures and borderline conditions are more plentiful than typical stands.

Utilization of the natural succession of vegetation appears to be one of the best opportunities for changing the character of woodlands to favor fox squirrels.

Chapter 3

THE SQUIRREL HARVEST AND MICHIGAN'S MANAGEMENT PROGRAM

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THE ANNUAL SQUIRREL CROP

WE NOW have a fairly good idea of the kinds of woodland occurring in southern Michigan, their approximate distribution, and how they got there. The next logical question is, how many squirrels are supported by various types of range? Among the best indices of numbers in different regions are the annual kill statistics collected by means of the report card attached to each hunting license.

Hunting Kill Statistics

Hunter's reports gave a measurement of the state squirrel harvest for the first time in 1939. In that season 150,339 sportsmen killed approximately 619,421 fox squirrels, or an average of 4.12 for those small game hunters who were successful in getting at least one.[6] There evidently has been a progressive increase of fox squirrels in most areas from 1937 to 1942. The exception to this trend was 1941 when the animals received a setback in some habitats. As will be shown, however, the lower kill of that year was in part due to unfavorable hunting conditions (p. 334).

The trend of squirrel populations in the state appears to be expressed in the kill records up to 1942 (fig. 14). A larger kill was expected in that year because populations on study areas were above those of any other year, and reports indicated that this condition was widespread. It is possible that, although license sales were nearly up to "normal," preoccupation with war work prevented hunters from spending much time in the field. Many probably hunted pheasants on the first day and did little shooting beyond this. Such an explanation is in some measure supported by the proportion of squirrel hunters to the total of small game hunters. For the four years these figures were as follows:

	1939	1940	1941	1942
Small game hunters	538,026	537,630	610,000	573,837
Squirrel hunters	150,339	161,468	142,115	146,492
Squirrels per hunter	4.12	4.49	3.79	4.4

[6] It is this group which will be referred to as "squirrel hunters."

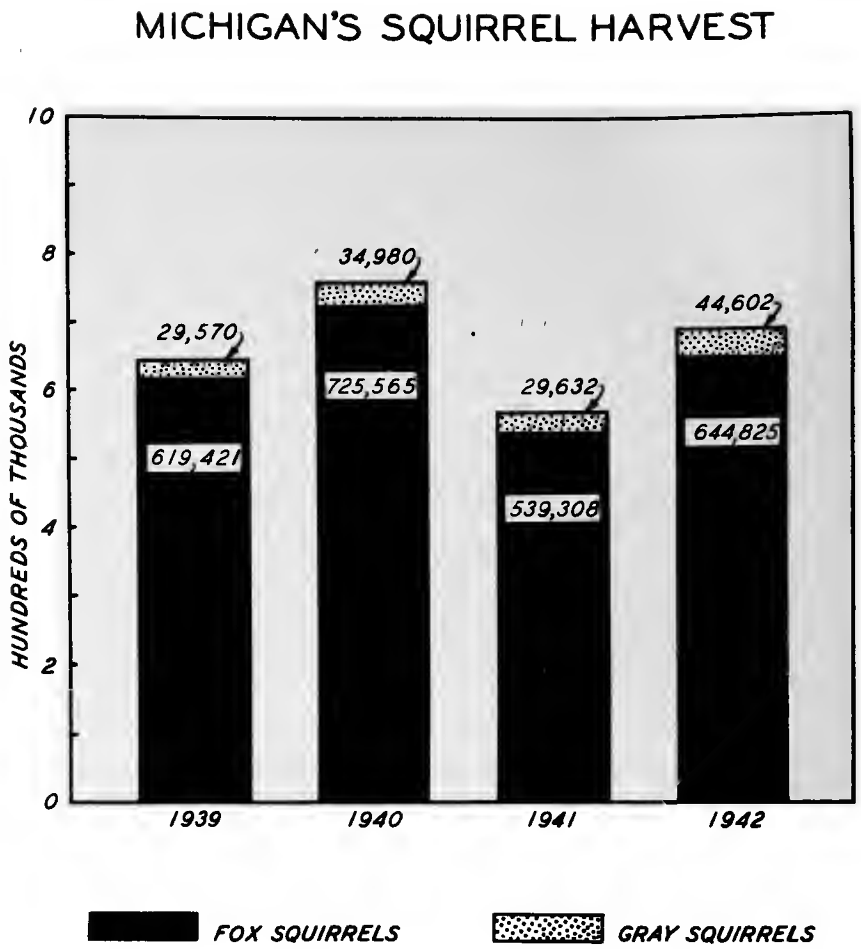


Fig. 14. The annual squirrel kill, as reported by licensed hunters on compulsory report cards, is in most years a good statewide index of population trends. Fox and gray squirrels probably reached their maximum numbers for recent years in 1942. The kill evidently is lower than would have been expected because war-busy hunters spent less time in the field than in normal years, and many of them give preference to pheasant and rabbit shooting. In the first two years of this series gray squirrels were hunted in an area equivalent to about nine counties (fig. 16). In 1941 the entire lower peninsula was opened.

In this series the year 1940 had the least small game hunters but the most squirrel hunters. The following year had the most small game hunters but the least squirrel hunters. The probable explanation of this is that the designation "squirrel hunters" is a somewhat artificial one. The more plentiful the animals are, the more

small game hunters will see and shoot them and by reporting them be classed as squirrel hunters. Thus this group fluctuates annually to some extent with the numbers of the fox squirrel. Probably all of the factors involved are not fully known, but it appears that in 1942 hunters were not attracted to and did not spend time on squirrel shooting to the extent that they do in ordinary years. It is likely that for the duration of the war, kill records will need some interpretation to be used as indices of squirrel abundance. In "normal" times such records should be usable in this way and to a great extent comparable from year to year.

The fall of 1940 witnessed what is probably the largest fox squirrel harvest ever taken in Michigan. In that season, out of a total of 537,630 small game hunters, 161,468 reported shooting 725,565 animals for an average of 4.49. There is little doubt that a larger kill than this would have been taken in 1942 had unusual conditions not developed. These kill records do not include the unlicensed farmer, and the figures would be raised to an unknown, but doubtless significant, extent if they could be completed. What the maximum squirrel crop should be under present conditions is not known. It is probable that the *available crop* in 1942 was near the maximum, but the actual kill certainly was considerably less than what could have been taken without harm to the next year's supply. Management includes producing more squirrels and also finding ways to utilize the available supply as completely as possible. There is no precedent by which to judge how much the annual harvest can be raised, but it seems reasonable to expect a fairly frequent attainment of the million mark for fox and gray squirrels in future years.

Considering weather, the mast crop, and those other factors which affect fox squirrels most vitally, 1939 was a representative favorable year for the species in Michigan. Hence the statistics for that season are used in the sample break-down in figs. 15 and 16. A comparison of the kill by counties with the map showing natural land divisions (p. 44) indicates that the lowland clay plains lying along the eastern side of the state from Saginaw Bay to Monroe County are southern Michigan's poorest squirrel range. The southwestern prairie counties are still the best, as they were in primitive times. It is evident that those areas which have a high productivity of fox squirrels are predominantly sand and clay uplands with a high percentage of moraine and outwash soils. Figs. 15 and 16 compared with the map of Michigan's original forests (p. 23) show definitely that the southern hardwood region is Michigan's produc-

tive squirrel range and that the northern portion of the peninsula is marginal for the species. Kill records bear out the conclusion in Chapter 1 that the management program should be confined to the southern area where fundamental (non-controllable) factors such as climate, soils, and forest types favor fox squirrels, and where local secondary factors can be managed.

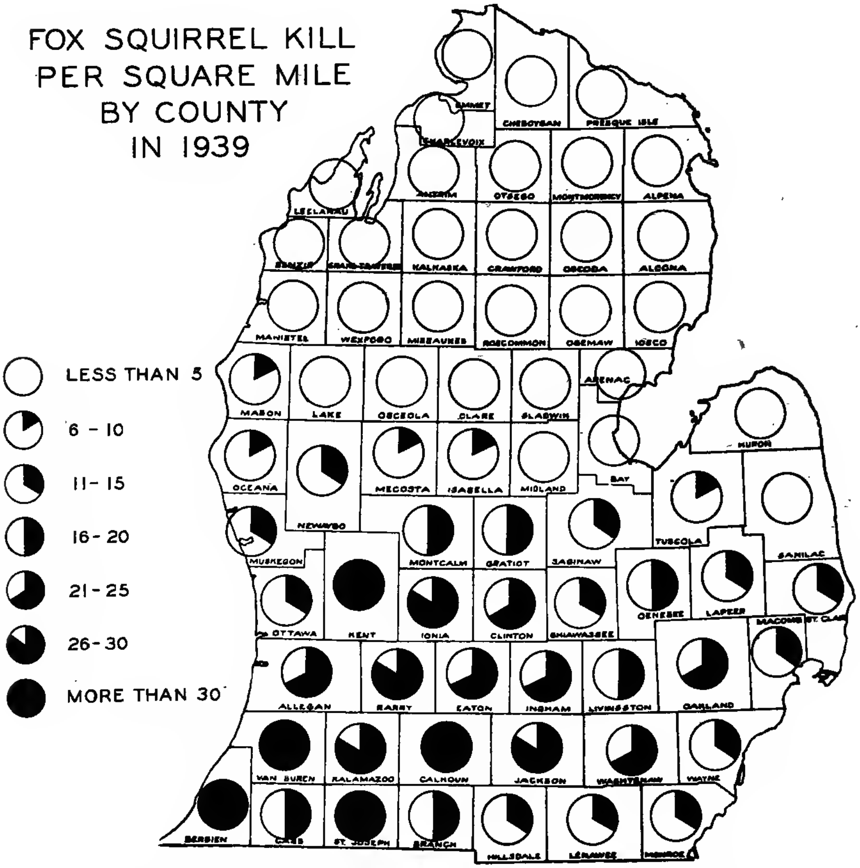


Fig. 15. The fox squirrel kill per square mile shows that the southwestern counties are still Michigan's best squirrel range. This map can be compared with figs. 4 and 7.

Hunting Yields of Woodland Types

If one county were covered entirely with scrub oak forest, another with beech-maple, a third with oak-hickory, and a fourth with lowland timber; if these counties had equal acreages of woodland and were hunted by equal numbers of hunters; and if these hunters reported their success, and there were lots of them so that individual errors would be submerged in the mass of data—then we would have an excellent measure of the relative squirrel-producing capacity of Michigan's most important kinds of woodland.

But unfortunately there are no such counties. Nearly all of the southern ones (counties are the units by which kill records are reported) contain timber varying markedly in composition from one part to another. The oak-hickory runs from near-scrub-oak on the poorest, highest, and driest soils to "rich" mixtures of red oak, beech, basswood, and other trees which grade into beech-maple in the state's best farmland. As a sample of squirrel range almost any large tract in southern Michigan is sufficiently mixed to complicate the picture.

This is especially true of the eastern counties with lakebed soils and lowland timber, and those in the north containing scrub oak. In both there is sufficient woodland of other types to alter, and especially to raise, the squirrel productivity of the counties. A comparison of beech-maple and oak-hickory woodlands, however, appears to be valid. An examination of the map on page 44 shows that Clinton, Eaton, and Genesee Counties have a higher percentage of beech-maple woodland than any other type, and in Jackson, Oakland, Calhoun, Barry, and St. Joseph Counties most woodlands are composed primarily of oak and hickory. Of course, all of these have lowland types in the bottoms, and each has areas of woodland not of the predominant type for the county. On the other hand, tables 2 and 3 show that there is a good consistency in the amount of hunting, woodland area, and kill in the counties selected as representative of each of the two forest types.

The graph in fig. 17 compares the hunting pressure and squirrel yield of the two groups of counties, respectively, in which beech-maple and oak-hickory woodland predominate. Although hunting in the oak-hickory range was 15 percent heavier, the kill was 37 percent higher, indicating a relatively more dense population of squirrels. The kill per hunter also showed oak-hickory range to be

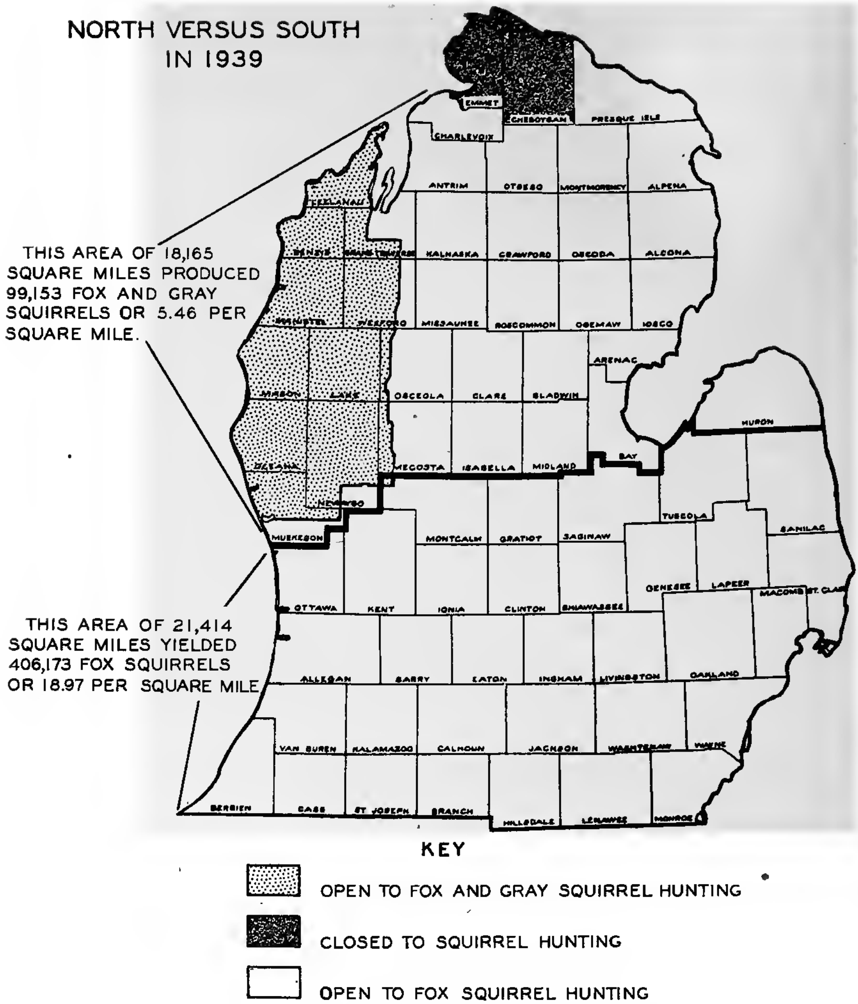


Fig. 16. Kill records verify the conclusion that the southern hardwood region is the area naturally adapted to squirrel production. The climate with its cold winters and other adverse effects in the north is a factor that can not be managed.

more productive. The average hunter killed 4.4 squirrels in this type, and 3.7 in beech-maple.

County statistics show that in general oak-hickory woodland is the state's best squirrel habitat. In 1939 St. Joseph County had the highest squirrel productivity per woodland unit of any county

in the state. The woodlots of that county yielded 63.7 fox squirrels per hundred acres, and the average hunter got 5.4 animals. In 1940 these figures were 82.4 squirrels per hundred acres and 5.84 squirrels per hunter. It is significant that this, probably the best squirrel county in the state, has also a higher percentage of second-class agricultural land than any of the other southern counties (103). In general, oak-hickory woodlands are found on soils which because of fertility or topography are second-class from the standpoint of agricultural production. First-class soils are usually occupied by beech and maple, lowland trees, or mixtures of these. In the southern half of lower Michigan the 5 counties having the highest percentages of first-class agricultural land produced 3.54

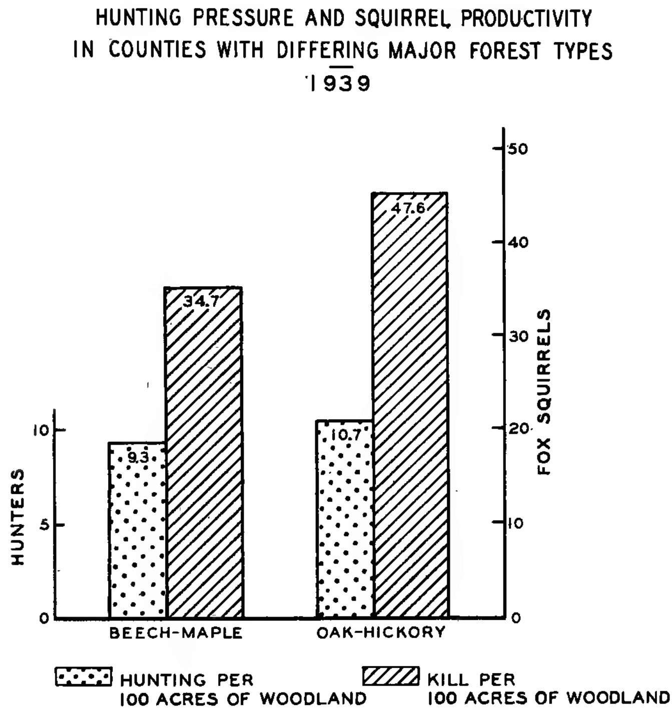


Fig. 17. The hunting statistics by county give evidence that oak-hickory woodlots are the state's best squirrel range. The above comparison was made by plotting the average hunting pressure and squirrel yield per hundred acres of woodlot for the two groups of counties given in tables 2 and 3. The counties with predominantly beech-maple woodlands are Clinton, Eaton, and Genesee. Those with oak-hickory as a major forest type are Jackson, Oakland, Calhoun, Barry, and St. Joseph. In the oak-hickory range hunting was 15 percent higher, but the kill was 37 percent higher.

squirrels per hunter in 1939. The five counties having the highest percentages of second-class land yielded an average of 4.48 squirrels per hunter.[7]

TABLE 2

Statistics on Squirrel Productivity in Counties with Predominantly Beech-maple Woodlots — 1939

County	*Acres of woodlot*	*Hunters*	*Hunters per 100 acres*	*Kill*	*Kill per 100 acres*	*Squirrels per hunter*
Clinton	37,306	3,384	9.1	13,989	37.5	4.1
Eaton	36,974	3,150	8.5	11,990	32.4	3.8
Genesee	34,825	3,601	10.3	11,874	34.1	3.3
All three counties	109,105	10,135	9.3	37,853	34.7	3.7

TABLE 3

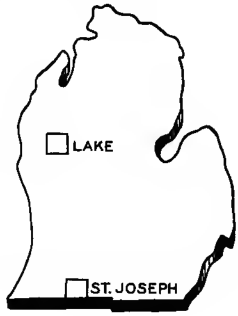
Statistics on Squirrel Productivity in Counties with Predominantly Oak-hickory Woodlots — 1939

County	*Acres of woodlot*	*Hunters*	*Hunters per 100 acres*	*Kill*	*Kill per 100 acres*	*Squirrels per hunter*
Jackson	40,702	4,619	11.3	19,205	47.2	4.2
Oakland	41,740	5,015	12.0	18,638	44.7	3.7
Calhoun	40,297	4,783	11.9	22,161	55.1	4.6
Barry	41,511	2,953	7.1	14,157	34.1	4.8
St. Joseph	25,503	2,989	11.7	16,236	63.7	5.4
All five counties	189,753	20,359	10.7	90,397	47.6	4.4

The excellent squirrel range of St. Joseph County seems to be characterized principally by the predominance of oaks. The woodlands contain a high proportion of black oak, and there are numerous clumps of bur oak, white oak, and hickories growing in the open and along roadsides (fig. 18). From Michigan southward the oaks probably are a much more dependable source of mast than they are in most of this state, where climatic factors may in some years

[7]In the first group are Clinton, Eaton, Genesee, Lenawee, and Sanilac Counties. In the second are Ingham, Barry, Livingston, Montcalm, and St. Joseph.

cause a complete failure to bear acorns. Much of the woodland in St. Joseph County contains relatively little hickory or other species. Although in most of the state 1940 was a year of almost complete failure in the oak mast crop, the southern counties probably were less affected than those in the north. As an indication of this the squirrel yield in St. Joseph County decreased less than 20 percent from 1940 to 1941, but the squirrel crop in Lake County decreased 52 percent in the same period. The quality of Michigan's squirrel range depends both upon the forest type composing it and upon the latitude of any given area.



THE MANAGEMENT PROGRAM

Kill statistics have furnished a measurement of present squirrel production in various parts of the state. Improvement of these yields is the management objective. Such a program for the fox squirrel, or for nearly any game species, falls naturally into three phases: An inventory of range and its productivity; research on methods of improving deficient range; and the application of tested-and-proved measures on a large scale. Thus far we have covered the inventory.

Need for Facts

The farmer who rears his yearly flock of young chickens does so with a fairly definite knowledge of the various factors with which he must deal. We should know something about chickens, since they have been living in man's backyard for several thousand years. In recent times, agricultural experiment stations and college poultry plants have been subjecting them to carefully controlled experiments utilizing the most modern scientific methods and equipment. Even so, poultrymen are the first to admit that there are many problems yet to be solved before all factors entering into poultry husbandry can be brought under control.

How about a wild animal like the squirrel? In comparison with the chicken, it is difficult to observe and even more difficult to count.

Fig. 18. St. Joseph County is the most productive county in the state for fox squirrels. One of the most significant characteristics of its landscape is the large number of mature oaks growing in fencerows and along roadsides.

Studying it is not easy, for it will not breed readily in confinement, and we learned remarkably little about it in the past because it was plentiful enough to supply all needs without any particular effort on our part.

Game animals have not had the attention which biologists have given, almost as a matter of course, to most wild things. The creatures inhabiting a farmer's rainbarrel are better known than those in his woodlot. There is a more detailed published account treating the habitat requirements of tiger beetles on Lake Michigan sands (88) than on those of fox squirrels in the woods a few hundred yards farther back. Songbirds have been the subject of numerous surprisingly complete and intimate studies. But game administrators have become increasingly aware that they have a very inadequate knowledge of the species for which they are called upon to determine open seasons, bag limits, and other regulations. As an evidence of this, several states at present have an open squirrel season at the time of year when females are caring for young in the nest. Shot-in-the-dark management is costly, as witness the closed squirrel season of 1938, which came at a time when the animals were plentiful in most of southern Michigan, and

which cost sportsmen the recreation involved in shooting about half a million first-rate game animals.

It is apparent to the wildlife manager that his most pressing need is facts. There must be a job of investigations designed to answer the most urgent questions now, and the less urgent ones later.

The Research Job

Practical range improvement necessitates a detailed knowledge of fox squirrel requirements. Hence, study projects must be set up on various sample areas to determine how the animals use different types of range and how one type provides basic necessities better than another. It has been found that nearly any fact which can be learned for sure about an animal is useful in the final analysis. Even if it has no direct application in range improvement, it will very likely help in learning something else that does apply directly. The important thing is that there be some basic plan to tie the various individual problems and accomplishments into a unified program.

The statewide plan

If everything could be done in logical order, an idealized research program for the fox squirrel would be something like this:

Sample areas which appear to be typical of the major range types would be selected and a man placed upon each area to learn everything possible about the fox squirrel and how it lives. Each man would have many questions in mind as he carried out his yearly program. How many young does the average squirrel produce in this habitat, and what factors contribute to such production? What percent of the young survive, and what are the principal causes of mortality? How many squirrels were present before the hunting season? How many were taken by the hunter? Did the hunter take too many, or less than the yearly "surplus?" Are food supplies adequate? Which foods are staple and which are merely incidental? Which can be most easily supplied where they are absent? What sort of winter nesting facilities does the squirrel require? Are the animals solitary in habit, or is the use of food, nests, and range communal? Do they maintain body condition in the winter? Does a severe winter harm them? To what

diseases, parasites, and natural enemies are fox squirrels vulnerable? In their yearly schedule what is the most critical time? On the basis of information thus far, what does it appear possible or practicable to do to increase the squirrel population? How do present hunting season regulations fit the life history of the animal and the interests of the particular group of sportsmen concerned?

Experience has shown that after several years of such study we should have some definite recommendations in the quarterly and annual reports of the men doing this work. They would select suitable study plots to try out their theories, keeping the best "controls" possible on their experiments. In the meantime they would be expanding their basic knowledge of the personal affairs of the fox squirrel, comparing results on one area with those on another, checking populations and habits one year with the next, and accounting for all changes and differences as completely as possible. In this way the deficiencies of each range type could be determined and methods found for remedying them. That is the theoretical way to set it up.

But things do not go quite so smoothly in actual practice. There are unforeseen limitations. Not all the steps can be taken in their logical order. The proper area, the proper man, and the proper equipment may not be available at the proper time. Sometimes it is necessary to do the next best thing. Such a program can seldom be set up on a wide scale all at once. It must be done piecemeal by making the most of opportunities as they are presented. The more-squirrels issue is by no means the only conservation problem, and with efficient management several can sometimes be dealt with at once. If there is a plan, each bit of information can be fitted into its place as the work is done, and by and by the puzzle will make a picture.

Exact information makes it possible to tell the interested farmer what can be done at little cost to improve conditions for squirrels on his land. The sportsmen's group who have a tract of land to manage can be advised how best to spend their money and efforts. State land can be developed to an extent that will pay the hunter a proper eventual return on his dollar. To perform our trial-and-error experimentation on a small and economical scale—that is the main function of game research.

Squirrel Investigations in Michigan

The Department of Conservation has sponsored several fox squirrel investigations during the past five years. The first was made by the writer as a part of a general wildlife study on the W. K. Kellogg farm (of Michigan State College) in Kalamazoo County, from 1935 to 1937. This project consisted mostly of population work in the oak-hickory woodlots of that area. The second study, also made by the writer, was carried out in scrub oak and riverbottom woodland at the Swan Creek Wildlife Experiment Station in Allegan County. It consisted principally of work on populations, breeding, and habitats and continued from 1937 through 1939. At that time Robert D. Montgomery took up the investigation as a Pittman-Robertson project (17) and continued it through the summer of 1941. Montgomery and his successor, Philip S. Baumgras, have kept up the population and breeding studies, and tests are now being made of habitat improvement methods for scrub oak lands.

In 1940, squirrel studies were instituted by the writer and others at the Rose Lake Wildlife Experiment Station in Clinton County. This inquiry has consisted of population inventories and tests of various management measures in the oak-hickory woodlots at the station. Station personnel have also done some work in the predominantly beech-maple woodlots of Michigan State College near the campus; and through the coöperation of the Conservation Institute, several students have carried on trapping, marking, and similar activities on squirrels in the college woodlots.

Squirrel Studies in Other States

Fox squirrel investigations in Ohio, Missouri, and Texas are the best out-of-state sources of material. From 1936 to 1940 Luther L. Baumgartner made extensive studies of the species over the state of Ohio. His work included populations, feeding, nesting, and other habits with a view toward conclusions on management. For several years ending in 1941, Harold V. Terrill did extensive field work on the fox squirrels of Missouri. He obtained especially good information on feeding habits, movements, and the effects of various weather conditions on populations and breeding. Beginning in 1936, Phil D. Goodrum conducted fox and gray squirrel investiga-

Chapter 4

FOX SQUIRREL NUMBERS

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POPULATION STUDY TECHNIQUES

WHEN A FARMER points to his 10-acre woods and says there are "lots" of squirrels there, does he mean five, ten, twenty, or fifty? To a hunter an abundance of game usually means that he can get a satisfactory amount of shooting in a given length of time. But a great variety of answers will be received when one tries to have such terms as "lots," "plenty," "fair amount," and "few" reduced to figures. To one person a squirrel per acre represents abundance, while another visualizes half a dozen per acre as a high population. This applies not only to farmers and sportsmen, but to wildlife technicians as well. When these studies started there were no figures in print which would give a reliable idea of the numbers ordinarily attained by our woodlot squirrels. The game manager must deal in fairly exact terms, and recent work has been especially valuable for setting up standards of expression.

Squirrels are commonly spoken of in terms of animals per acre of woodland, or acres per animal. This is probably the best that can be done, even though it is somewhat misleading. A fox squirrel makes good use of the open land near the trees where its nest is located. In fact its habitat is the edge of the woodlot, just as it formerly was the edge between the prairie opening and the forest. This explains why small woodlots often have a higher per-acre population than do large ones. A 10-acre plot has only three and one-half times the "edge" of a one-acre unit. How much land a squirrel uses cannot be stated. It varies with the pattern of fields, the size and shape of woodlands, and possibly with the abundance of the animals themselves. Squirrel kill records have already been used in terms of county woodland acreages. Although this is a useful way to compare range productivity, the figures cannot be strictly applied because they attribute to woodlands the yields of trees in fencerows, dooryards, and other places not included in the woods acreage.

Inventory Metnods

Counting wild animals has been one of the most perplexing of the wildlife manager's problems. Several methods have been tried for squirrels, with varying degrees of success.

Time-area count

One way is for an observer to seat himself in the woods and remain quiet for a given period at a time when these animals are active. All squirrels seen are counted, and the area of visibility measured. By this method Goodrum (43, 44, 45) conducted extensive surveys of gray and fox squirrels in Texas. The method has also been well analyzed by Hicks (56) in Iowa who obtained information on activity in relation to time of day, weather, and other factors by using it. The technique works best in large units of fairly uniform cover and doubtless produces most consistent results where all of the sampling in different habitats is done by one man. Trials of the method in Michigan indicate that under these conditions it is of greatest value as an index of relative numbers rather than as a source of data on squirrels per acre. Work on methods of this type is worth while, for one of the greatest needs in practical game management is for *extensive* inventory methods whereby a few men can get a reliable statewide estimate of animal numbers in

Fig. 19. Fox squirrels do not always live in woodlots. This combination supported one individual all summer at the Rose Lake Wildlife Experiment Station.

a short period of time. To date most of the Michigan work has been intensive; that is, the methods used are more time consuming, but as accurate as we can make them. Of course, such work has yielded other information in addition to census figures, and has provided a good basis for the development of shorter techniques.

Nest counts

Nest counts were also used by Goodrum as an index of squirrel populations, although he expressed some dissatisfaction with their accuracy in some habitats (43). In Michigan this kind of work has yielded disappointing results. "Nests" vary from a mere handful of leaves to bushel-basket size; they occur in every state of construction and disrepair; they are difficult to locate when the leaves are on; some nests are constantly being torn out by squirrels or other animals; they are less plentiful where tree dens are numerous; and the hunting season or a winter die-off may leave few squirrels but many nests. Nest counts over a three-year period (6, 75) at the Swan Creek Wildlife Experiment Station, in a woods where the population was being closely followed by box-trapping and tagging, have failed to show any consistent correlation between the number of nests and the number of resident animals. The future may reveal some way in which they can be used, but so far nest counts have proved unreliable for censusing fox squirrels in this state.

Other indices

The number of squirrels treed by a hunting dog in a given length of time was employed in the Texas studies for indicating relative numbers of squirrels in different habitats. In Michigan the number of tracks seen on new snow when squirrels are active has served the same purpose. These are good indices of "scarcity" or "abundance," but do not convert readily to "resident squirrels per acre."

Trap census

Although by no means perfect, the best census method found so far has been to trap and mark all squirrels on a given area. This technique has been used in all investigations in this state and was employed by Baumgartner in his Ohio surveys (11). The idea is

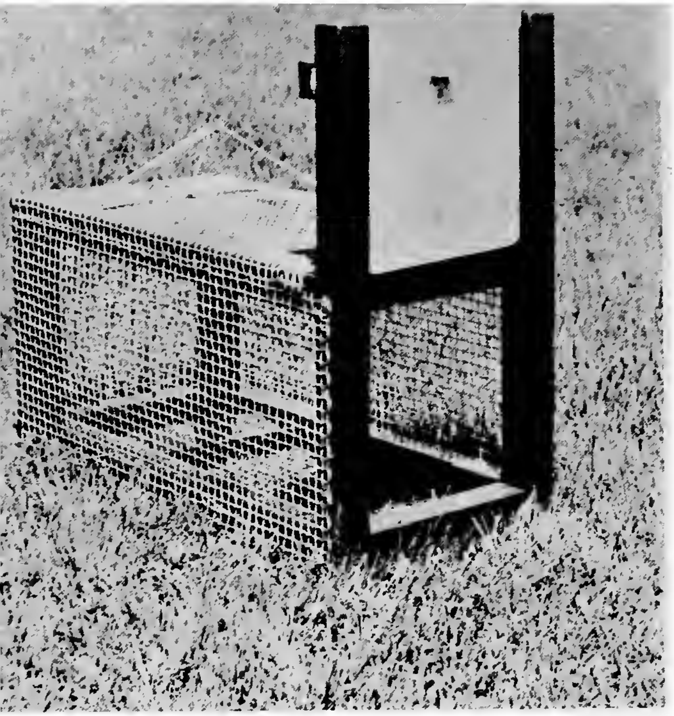


Fig. 20. The box trap used in Michigan squirrel studies.

to set enough live-traps in the area to be censused to catch all squirrels in a relatively short time. As each squirrel is caught, it is ear-tagged and liberated. When no new untagged animals are taken, that is, when all of those handled are "repeats," the number of individuals caught in the course of trapping should represent the total number using the study plot.

Trapping and handling squirrels: Box traps a foot square and two feet long, covered with half-inch mesh, 16-gauge, galvanized hardware cloth (fig. 20) have been successfully used for catching squirrels. This trap is not ideal because it leaves the animals exposed to weather, but in Michigan wildlife studies it was found most economical to develop a trap which could be used on all small game mammals. Set in squirrel study areas, it also takes skunks, woodchucks, opossums, raccoons, rabbits, weasels, mink, and smaller animals. Conversely, numerous squirrels are handled in work on other species, and thus more information is obtained for time spent. In Ohio, Baumgartner (10) used a trap with sides of wood and a heavy glass plate, to admit light, in the end opposite the door. This

protects the animals from weather and materially reduces trap mortality. Considering squirrels alone, it is much the better trap.

An effective and practical bait for fox squirrels is ear corn. It has been used in all Michigan projects. Various nuts are also good, although they are less available and more expensive than corn. Montgomery (75) found cracked walnuts to be effective at some seasons, and especially attractive to gray squirrels.

Removing a squirrel from a trap is not something to be undertaken carelessly, for these animals have efficient equipment for biting and scratching. It can be done, with some practice, by seizing the squirrel around the neck and shoulders with a hand protected by a heavy leather mitten. A better way to handle such aggressive animals was used by F. W. Stuewer in his raccoon studies at Swan Creek (94). He constructed a cone of inch-mesh poultry netting similar to the funnels sometimes used on fur farms. This was placed across the opening of the trap and the animal driven into it. The cone was then compressed behind the squirrel and held with a harness snap. Squirrels can be handled readily in this manner, and cones have been useful in the state projects.

Marking: The band now in use is the number 3 mammal ear tag of the National Band and Tag Company, Newport, Kentucky (fig. 21). These are not entirely satisfactory, since squirrels sometimes lose them, but their use is necessary for getting returns from hunters. Each tag is inscribed "Cons. Dept., Lansing, Mich." and bears a number corresponding to a record card on which the history of the individual is kept. Valuable information on hunting kill and distribution has been obtained from tag numbers returned by hunters.

To eliminate errors resulting from lost tags, J. P. Linduska (69) at Rose Lake developed a method of ringing one of the hind toes of a fox squirrel with a loosely-fitting fingerling fish tag (fig. 21). Ear tags are also used, as they are less likely to be overlooked by hunters, and both tags together constitute the most satisfactory method yet found for marking squirrels.

Animals trapped and marked are examined for signs of age, breeding, disease, fat or emaciation, and any other condition worth noting, and are weighed at each handling. Young squirrels examined in the nest are marked by a system of toe-clipping. How this information contributes to our objective of "more squirrels" will appear in many places in this report.

Fig. 21. Fox squirrel tags and the method of application.

Errors in the trapping census: On paper it sounds rather easy to trap and mark all the squirrels in a woods, but it is not so simple as might appear. We can, for instance, consider some of the errors encountered in two years of work in a 40-acre scrub-oak woods at the Swan Creek Wildlife Experiment Station in Allegan County. The 36 traps, which were set in a checkerboard pattern, were operated in nine periods (7). At the end of two years, when the history of individuals was traced, it was found that three squirrels had skipped a trapping period and then were caught again. Two more skipped a period twice and were caught. One squirrel was not

trapped for three periods and then appeared in a trap. From these records one suspects that in any given period not all of the squirrels present in the woods were being caught.

Tending to counterbalance this error, if it is such, is the case of non-resident animals. An individual which merely wandered into the study plot, perhaps only a few times during its life, should hardly be classed in the "resident" population. But where an animal spends most of its time is difficult indeed to determine. An individual handled only once is always suspected of being a non-resident.

Another complication was that some squirrels scratched tags out of their ears and so could not be identified when recaught. Occasionally one would die of what appeared to be "shock" while being handled. A dog might break open a trap leaving no evidence as to what animal was taken. A trap would be stolen, and perhaps a squirrel with it. There are times when the wildlife investigator envies the farmer who can enter the poultry house at night with a flashlight and simply count the neatly-ranked pullets before him.

But each year sees new refinements of method, and new ways of eliminating errors. It has been found that squirrels liberated from a trap on snow can often be tracked to their nests and thus identified, in one sense, as residents or non-residents of a given tract. Trailing with a dog is still better for this purpose (7). Toe-ringing in addition to banding has solved the lost tag problem; and trapped squirrels with "shock" can in some cases be revived with dextrose injections (75). In spite of its difficulties, the exhaustive trapping method has proved to be the most satisfactory way to determine populations, and much of the information to follow was secured in that way.

Fig. 22. Good records on movements, distribution, age, and other aspects of the squirrel problem are secured when hunters return the tags of marked animals.

FOX SQUIRREL POPULATIONS IN MICHIGAN WOODLANDS

Our best evidence as to the relative carrying capacity of woodland types in this state comes from population figures on sample units of various areas. The annual kill for different parts of the state was discussed in Chapter 3.

Numbers in Scrub Oak Range

Allegan County

Practically all of Michigan's squirrel work in scrub oak woodlands has been done at the Swan Creek Wildlife Experiment Station. In the approximate center of Allegan County is a tract composed for the most part of "Plainfield sand" about 100,000 acres in extent. This supported the southernmost large stand of pine in the state, and it was logged off more than 60 years ago. The area was burned over repeatedly and then broken up into farms. The light soil quickly became depleted and unfit for any known kind of agriculture. Sand "blowouts" appeared, and wind erosion threatened to convert much of it into a desert. In its resettlement program, the U. S. Department of Agriculture purchased the poorest portion of the area, and this is now being administered (under a long-term lease) by the Michigan Department of Conservation as the Allegan State Forest and the Swan Creek Wildlife Experiment Station.

Following cutting of the pine, scrub oak became the dominant forest type in the sand plains. It is now spreading rapidly in the old fields (fig. 23). Most of the tract is of this type, but the Kalamazoo river, which cuts across it, forms a floodplain a quarter to half a mile in width. These riverbottom woodlands have also been included in the squirrel program at the station.

In the fall of 1937 a 40-acre woods representing about average "oak-grub" conditions was selected as a sample census area. Thirty-six permanent trap locations were laid out in a checkerboard pattern, and the woods has been censused at each season of the year since the work began. In addition, there have been study projects on the rabbit and raccoon at the station. Ear corn was included

Fig. 23. Airphoto of Allegan County scrub oak woodlands. The 40-acre woods used for intensive squirrel population studies is indicated by the arrow at lower left.

in the bait of extensive traplines operated for these animals with the result that many fox squirrels were caught. In a four-year period more than 1200 individual squirrels were handled alive at Swan Creek. Although there was an open hunting season in each year except 1938, the 40-acre "squirrel woods" itself was posted against hunting.

In the first part of 1938 so little trapping was done that the figures are not significant, but in the 6 months from December 1938 through May 1939 a total of 15 females and 19 males were accounted for in the squirrel study woods. For the same period in 1939-40, 24 females and 31 males were handled. These figures indicate that an increase in squirrels occurred. Of course they include far more than the population actually resident at any one time. From point of numbers, the "high" of the year was fall, with 19 animals handled the first year and 24 the second. Mid-winter was much the same in the two years, with only 6 and 7 squirrels accounted for. There were 12 in March and April of 1939 and 16 a year later. From the results of trapping in the different periods it was apparent that there was a large turn-over in the population of the woods from season to season.

The longest known residence of a squirrel in the woods was 2 years and 5 months. Another animal was known to frequent the tract for nearly 2 years, and another for 16 months. But such long periods of apparent residence were exceptional. In the four years of trapping 128 squirrels were known to be in the woods for a period of a month or less, and 51 were accounted for over periods of one to two months. In all of the Michigan work there have been indications of a tendency on the part of fox squirrels to move about.

Studies in the squirrel woods, and other Swan Creek traplines provide a fairly good basis for population estimates. In 1937 and 1938 the average pre-hunting density of squirrels in the scrub oaks was about one per 5 or 6 acres of woodland. In 1939 the population had increased to one per 3 or 4 acres, and a year later (1940) it had risen again to approximately a squirrel per 2 acres. After a small decline in 1941, the animals reached their greatest abundance for this period of years. The 1942 population can be estimated at about one squirrel per acre of upland oak woods.

Year-to-year trend in the scrub oaks

The above trend in populations is well illustrated by trapping records for the first three years of this work. The squirrel woods was too restricted to give entirely reliable data on populations in the entire region, and the raccoon and rabbit traplines were too scattered to permit the use of trapping results for computations of squirrel numbers on an acreage basis. But since such a large number of traps were being operated at the station, nearly 500 during the summer, the percentage of traps that caught squirrels each year is a fairly good index of population density. These percentages for the first three months of 1938, 1939, and 1940 are compared in fig. 25. There is no reason to doubt that they are closely indicative of relative population levels in the three years. The one known factor that might complicate the comparison is the relative abundance of natural foods. During the first quarters of 1938 and 1939, squirrels were living on the remains of oak mast crops about equal in quantity in the two years and "fair" as compared with maximum yields. The population of squirrels was small

Fig. 24. The scrub oak squirrel study woods at Swan Creek.

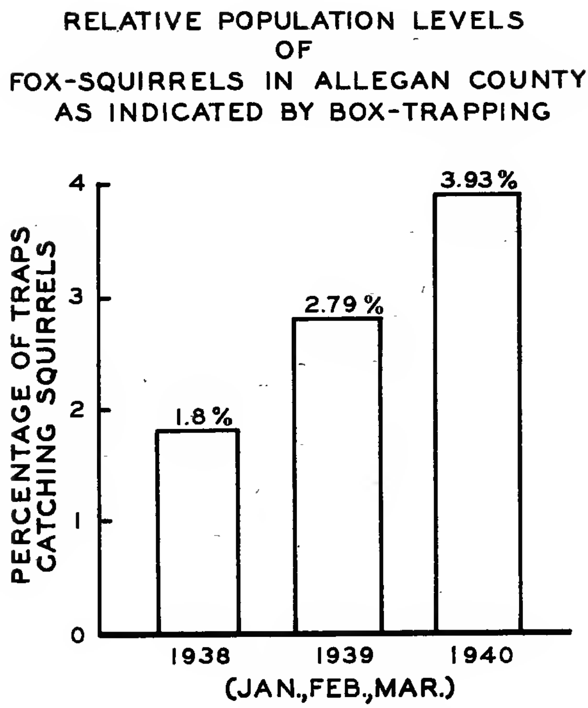


Fig. 25. In the Allegan County scrub oak woodlands fox squirrels increased each year from 1937 through 1940. This is illustrated by the relative percentages of box traps catching squirrels in the first quarter of each of the three years. One trap set for one day is considered a "trap-day," and this unit is the basis for the calculation of percentages. Trapping totals for the three years were 2,662, 6,763, and 1,499 trap-days, respectively.

in 1938 and somewhat higher the next year. The 1939 fall mast crop was very large, and a still higher squirrel population was using it in late winter (1940).

The more natural food available the less squirrels are attracted by ear corn in box traps, and vice versa. Hence, in the fall of 1940 when mast completely failed, the percentage of traps catching squirrels rose abruptly far beyond its significance as a population index. What happened with regard to populations and mast is traced in detail in fig. 26 and its accompanying explanation. Late winter conditions in the first three years are considered to have been sufficiently similar to justify the use of the data to indicate relative population densities.

Information from all sources makes it evident that squirrels in the Allegan County scrub oaks increased progressively from 1937 through 1940. As a result of an extreme mast shortage, numbers were somewhat lower in 1941. The "boom" times of 1942 were evident to everyone, although trapping was too restricted to permit use of the records as in fig. 25. Hunters had the best sport afforded by the "oak grubs" in many years. This in spite of the fact that winter mortality had caused the breeding population to drop somewhere below the 1940 level. In the scrub oaks squirrels are more vitally affected by mast yields than they are in habitats where food supplies other than acorns are available.

Effects of food shortage in 1940

The period 1937 to 1940 was increasingly favorable to fox squirrels. Populations steadily increased, and the abundant mast crop of 1939 provided optimum conditions for what was probably a maximum breeding stock. But in 1940 the green pastures turned brown. Both white and black oaks failed to bear, and an acute food shortage developed from midsummer on. Montgomery was studying the Swan Creek squirrels that winter, and he found ample evidence of malnutrition during the cold season. Mange (p. 209) was widespread, and all squirrels were thin and underweight. They were in no condition to breed during the winter, and by spring their numbers had undoubtedly declined. Details of this situation are discussed in Chapters 5, (p. 107) and 9 (p. 206).

Other evidence of a winter die-off in scrub oak habitats of the state was obtained by the writer and others in two days' field work in the spring of 1941 on the Luther-Baldwin State Game Area in Lake County. Fox squirrels, as well as grays and blacks, had been increasing in that region for several years previous. On May 8 and 9, 29 of the largest leaf nests that could be found were examined, together with 4 natural dens. Two dead fox squirrels were discovered, and only one nest contained a live animal, which was the only living fox squirrel seen in the course of two days' work. One other nest contained fleas and showed signs of recent use. This is a small sample, but it was evident that squirrels were scarce.[8]

[8]The capacity of squirrels for a quick "comeback" is shown by the fact that a year and a half later, in the fall of 1942, fox, gray, and black squirrels were at the greatest abundance in years in this area.

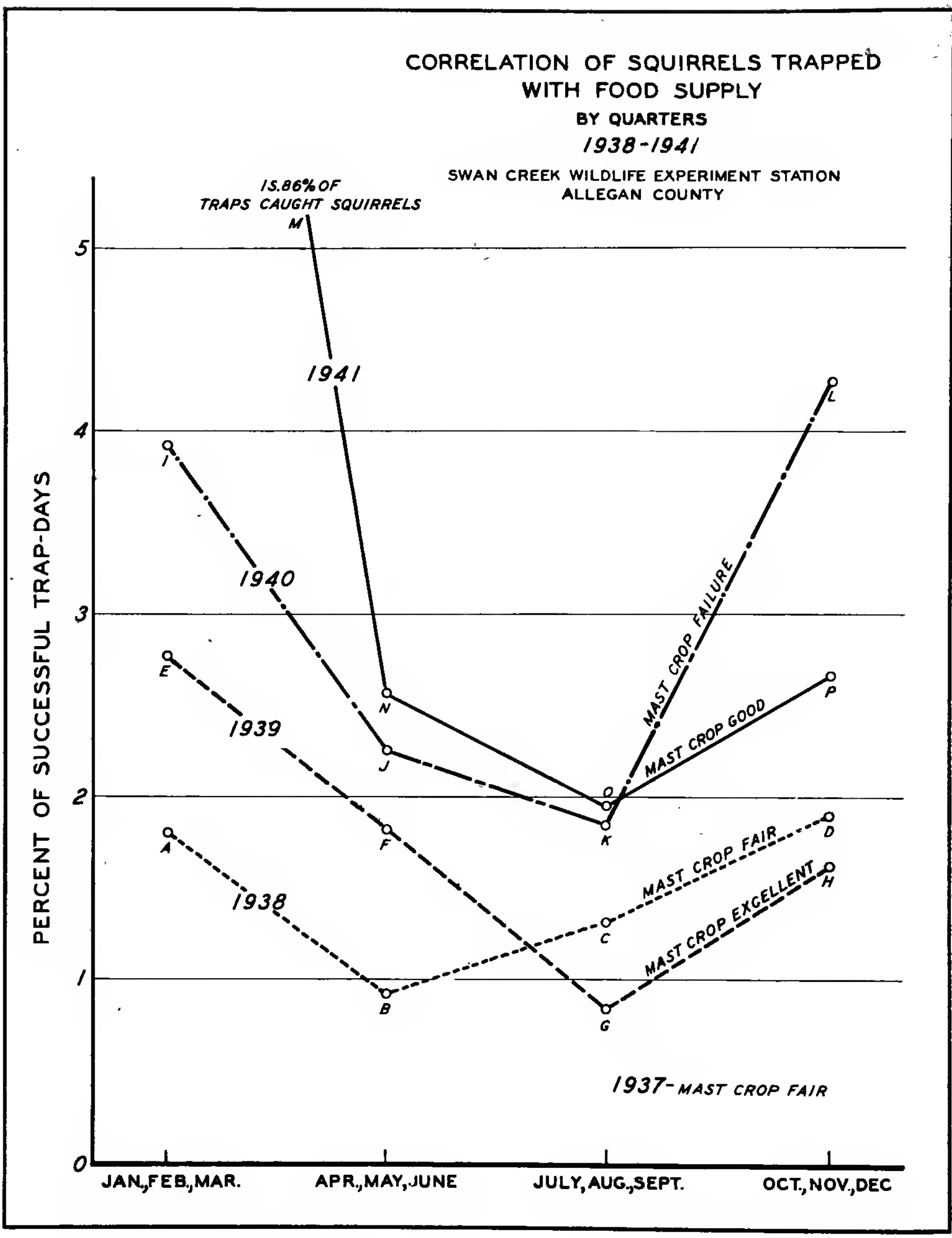


Fig. 26. On this graph each year's trapping in the scrub oak woodlands of Allegan County is represented by a line. Each of the four points on a line designates the percentage of trap-days which caught fox squirrels in that particular 3-month period. The size of the catch was governed primarily by two factors—the relative abundance of squirrels and the attractiveness of

That a winter die-off sometimes occurred under primitive conditions is indicated by a record from Charles C. Deam of Bluffton, Indiana. In 1925 he interviewed Calvin Deam, an old hunter and trapper of the last century, who stated that about the year 1863 the fox squirrel and the opossum died off over winter. There were sometimes half a dozen dead squirrels in hollow trees cut the following spring.

Carrying capacity of the oaks

At its best, that is, in a good mast year, the scrub oak habitat probably approaches our best squirrel range in carrying capacity. However, it is not dependable. There is no source of staple food except the oaks, and when these fail, privation results. Squirrels breed at the time when food shortages are most acute—in late winter. This intensifies the effect of dietary want, as individuals which do not actually succumb may lack the vigor to produce young. In this habitat populations can be expected to fluctuate radically, and this is even more true farther north. If these animals had been followed through several "ups and downs" in the oaks, it might be possible to say that in the fall their numbers averaged one per 4 acres. Probably that is a fair estimate for the Allegan tract. As one goes northward the carrying capacity of this type of habitat

ear corn bait in traps. The latter was to a great extent dependent upon the quantities of natural food available in the form of oak mast. The relative heights of points A, E. and I on the graph probably are good indices of population levels, as each of these three winters followed a fall mast production sufficient to prevent any great amount of malnutrition among fox squirrels. As winter snow melted and last year's mast became more available, the attraction of box trap ear corn decreased, and the percent of successful traps declined to points B, F, and J, respectively. In 1938 there was only a fair mast yield, and trap efficiency increased in late summer and fall. The squirrel population increased, raising the efficiency of late-winter trapping to a higher level (E and F) than in the year before (A and B). The winters of 1938 and 1939 both followed fall mast yields that can be designated as "fair," and the trend of the trapping was much the same from winter to spring (A to B, and E to F). In the summer of 1939 the best mast crop in years was maturing. Squirrels began using it in late summer, and the attraction of corn bait declined until late fall. With the coming of cold weather corn evidently was more appreciated, and the catch percentage went up. The population had again increased and stood at a new level (I) for late winter. Much of the 1939 mast was still available through to midsummer in 1940, and with the passing of cold weather and deep snow, trap efficiency declined. But when a new crop of mast should have ripened in 1940 the most acute failure in recent years occurred. By late fall the abundant mast crop of 1939 had been exhausted, food was scarce, and squirrels were coming regularly to the traps. During the winter many animals died, directly or indirectly from lack of food, and by the end of winter, trap effectiveness had risen to an unprecedented high point of more than 15 percent (M). This in spite of the fact that winter mortality had caused the population to drop somewhere below the 1940 level. In the scrub oaks squirrels are more vitally affected by mast yields than they are in habitats where food supplies other than acorns are available.

declines rapidly and becomes almost negligible in the northeastern counties. The important thing is that in the southern management region we now know scrub oak to be only "fair" squirrel range, and have a pretty good idea why.

Squirrels in Oak-hickory Woodlots

In the department program there are two areas where oak-hickory woodlands have been studied as squirrel habitat. The 1935-37 farm-game project at the Kellogg Farm in Kalamazoo County included trapping and observations on the fox squirrel; and since 1939, squirrel investigations have been an important part of the program at the Rose Lake Wildlife Experiment Station in Clinton County.

Kalamazoo County

In 1935-36 fox squirrels were plentiful in the farm woodlots of Kalamazoo County. The Kellogg Farm and adjacent Midland Park on Gull Lake are closed to squirrel shooting, and hence the sample is not entirely representative of the bulk of southern Michigan; but in the first three months of 1936 a total of 61 individual fox squirrels were trapped in about 30 acres of woodland (3). No attempt was made to separate residents from non-residents, but evidence indicated that the breeding population of fox squirrels in that area was in excess of one animal per acre of woodland.

In late winter and spring of 1936 animals of this species began to appear with patches of hair missing. There were numerous reports of "naked" squirrels in the vicinity, and several specimens, emaciated and nearly hairless, were found dead (see scabies, p. 209). During the following fall and winter, with considerably more trapping than in the previous year, only 39 individuals were caught and marked. From these figures and general observations, it was evident in the spring of 1937 that their numbers were only about half what they had been a year before.

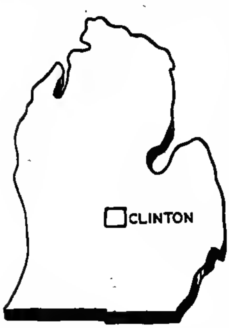
The work in Kalamazoo County was significant chiefly in three ways as far as squirrels are concerned: It proved that oak-hickory

woodland can support a relatively high concentration of these animals; it showed that protection from shooting does not insure *continuous* abundance; and it indicated strongly that disease is an important mortality factor.

Clinton County

In the fall of 1939, trapping and other work was started on the Rose Lake area. Approximately 102 acres of predominantly oak-hickory woodlot, in seven units (fig. 27) on a centrally located 800-acre area, have been used for census purposes since that time. Traps located one to the acre have been operated in these woodlands at intervals throughout the year. Table 4 shows the squirrels taken in box traps during spring and fall, and the hunting kill, over a three-year period.

Squirrels taken in box traps are an imperfect index of populations unless such factors as the availability of food are taken into consideration. This has been demonstrated in the discussion of work at Swan Creek. The food factor has been much less important at Rose Lake, but it undoubtedly limited the survival of young animals in 1940 and breeding productivity in the spring of 1941. Some of the figures in table 4 are not easily understandable, but the general trend in fall populations has been evident. There has been a progressive increase in fox squirrels on this area since the fall of 1940. The pre-hunting trapping has showed this, and the hunting kill would also show it, had not unusually poor hunting conditions in 1941 prevented the harvesting of a portion of the available squirrel crop (p. 334).



The year 1942 represents the most favorable year studied on the Rose Lake area, and the trend in population was approximately as follows: A spring breeding stock of about 50 squirrels per hundred acres of woodland increased to a late-summer population of approximately 150 animals, of which the hunter evidently took well over half. It must be remembered that both trapping and hunting accounted for squirrels which can not be considered resident on the study area. After the hunting season in 1942 there were 40 fox squirrels accounted for in an 8-day trapping period. The estimates take all of these facts into consideration.

As a comparison with the Swan Creek figures, fall fox squirrels at Rose Lake have varied from about one animal per 2 acres to about 2 squirrels per acre in most of the woodlots. However, certain woodlots have fallen below the minimum mentioned, and in the fall of 1942 there were two having pre-hunting populations of near 3 animals per acre.

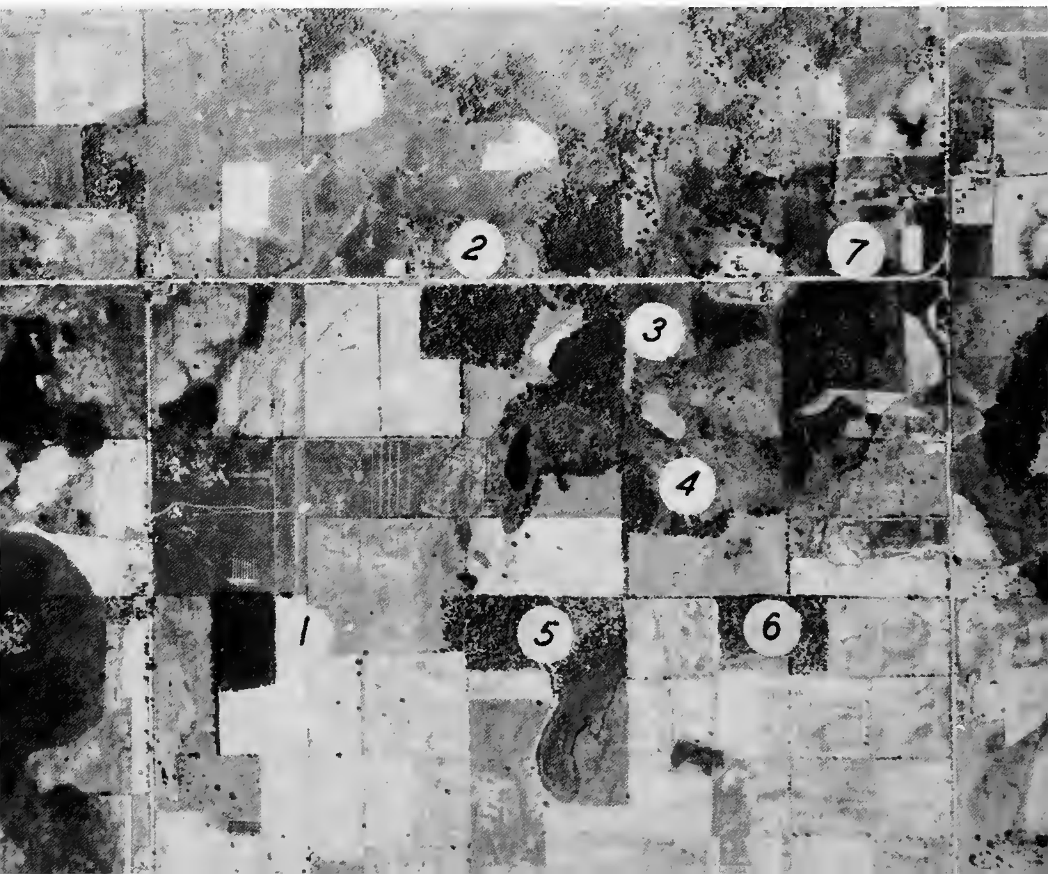
TABLE 4

Fox Squirrel Numbers in 102 Acres of Oak-Hickory Woodlot in Clinton County
(Rose Lake Wildlife Experiment Station)

	Taken in box traps		Hunting kill
	Spring	*Fall*	
1940	59	39	42
1941	61	110	42
1942	47	167	107

Fig. 27. The seven woodlots at the Rose Lake Wildlife Experiment Station upon which population records of fox squirrels are being obtained each year.

U. S. D. A. aerial surveys



Maximum numbers

Since the original home of the fox squirrel was prairie groves and predominantly oak-hickory woodlands adjoining openings, it is not surprising to find the highest populations in range of this type. Just how high populations can go is problematical, but on a basis of what we have seen so far it seems likely that 2 squirrels per wooded acre in the fall is near the maximum that any large area, say a township, supports.

Larger concentrations undoubtedly occur in good feeding areas. Conservation Officer F. C. Bishop reported a 10-acre woods in Clinton County where he saw 23 fox squirrels cross the road in an hour early one morning in October 1939. The animals were feeding under some outlying hickories. In the same vicinity a farmer acquaintance of Mr. Bishop knew of 53 fox squirrels being shot in his 20-acre woods that season.

It is not possible to say what the development of ideal conditions in and around woodlots might produce. Considering the small number of our samples, it is unlikely that the best habitats in the state have been studied. Perhaps some small woodlands with the proper surroundings support a fall population of four or more squirrels to the acre in good years. We can be confident, however, that all such populations will be unstable and that there will be "lows" to balance the periods of prosperity.

Beech-Maple Woodland as Squirrel Habitat

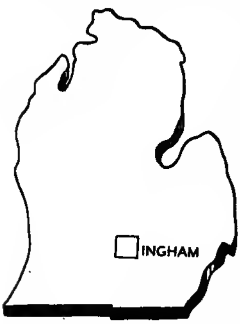
Some extensive sampling of squirrel populations in beech-maple woodlots was done by Baumgartner (11) in Ohio. In the agricultural lands of that state woodlots have been reduced considerably below the proportion existing in Michigan. Consequently, the units are more isolated and easier to census by the trapping method, due to the less frequent movement of animals from one woods to another.

In general, Baumgartner found this habitat type to have a lower carrying capacity for fox squirrels than oak-hickory. The average year-round population in beech-maple woodlots was a squirrel per two and a quarter acres, whereas the corresponding figure for oak-hickory samples was an animal per acre and a half. Populations

fluctuated from year to year, declining an average of 34 percent in 1937, rising 6 percent in 1938, and decreasing 35 percent in 1939.

In November 1940, Montgomery censused a 19-acre beech woodlot in Allegan County. He found that the woods contained many red squirrels, and he tagged 11 fox squirrels. The mast crop was a failure, but cornfields bordered the woods on two sides. The owner had not allowed hunting in the tract for three years. For the fall season, when squirrel populations should be at their height for the year, the number of animals found was not large. In the spring of 1941 another trapping period in this same woods indicated a population of 10 animals. In a 6-acre woods nearby 7 fox squirrels and 11 red squirrels were trapped and marked.

Coöperating with the Rose Lake staff, Lloyd C. Hulbert did some fox squirrel trapping in an 18-acre beech-maple woodlot in Ingham County in the fall, winter, and spring of 1940-41. During and after the hunting season he accounted for 31 fox squirrels, 26 red squirrels, and 7 flying squirrels. Even if all of the fox squirrels were not residents, the figures probably are large enough to indicate a population well over a squirrel per acre. This woods contains large mature trees, and a thriving reproduction. It is rather open due to recent selective cutting. Beeches and maples are the most plentiful species and there is a scattering of oaks, elm, and ash. Although predominantly beech-maple, the unit can properly be considered a mixed type, and its squirrel population compares favorably with that in good oak-hickory range.



One of the Michigan State College woodlots was trapped during the fall of 1940 by three students. In the "river woodlot," a 55-acre tract of mixed beech-maple and lowland trees, they marked 39 fox squirrels, 40 red squirrels and 3 flying squirrels. There are numerous unknowns, but the fox squirrel population evidently was an animal per 1 to 2 acres. The woods is not hunted. It has a thrifty understory and is well mixed with oak, ash, elm, basswood, ironwood, cottonwood, and other species. This is another example of an area with red squirrels and fox squirrels evidently getting along successfully together.

In 1940-41 the Conservation Institute at Michigan State College coöperated with the Zoology Department and the Rose Lake staff in another job of trapping in college woodlot 17 near the campus.

This unit of 68 acres is well isolated and composed predominantly of beech and maple mixed with lowland trees. Fifty-six fox squirrels, which probably fell considerably short of being the entire population, were trapped and tagged during the period July 18 to October 1, 1940. In the spring of 1940 an attempt was made to remove all fox squirrels from the woods. Twenty-nine traps were operated from February 27 to March 20 and April 7 to May 24. In this time 62 animals, which doubtless constituted most of the breeding stock of the year, were removed to other areas. Here is another good example of a "turn-over" in population: for even though 56 squirrels had been ear-tagged the summer before, only two of those taken in the spring had been previously handled. Another significant fact is that after two and one-half months of trapping new squirrels were still being taken.

Fall concentrations of squirrels are common in beech woodland. In those infrequent years when mast is plentiful, large kills are sometimes made in groves of mature trees. Two Allegan hunters reported shooting 20 squirrels in two days in a 10-acre beech woods. Montgomery was told that in 1940 about 25 fox squirrels were shot in the 6-acre woodlot sampled by him the following spring. Such stories are common among hunters, and it is evident that good feeding areas sometimes yield much more game than could possibly have been raised on them. If these tracts were cropped according to what it might appear advisable to take on a per-acre basis, the chances are that in the region as a whole the total "annual surplus" would not be taken. This matter of cropping squirrels is discussed on page 341.

From indications obtained in Michigan, beech-maple woodland, especially where it is mixed with oak and other trees, may be excellent squirrel range. Where it occurs in pure stands, however, the beeches are practically the only source of mast, causing the habitat to be favorable one year and poor the next. That it is inferior, on the average, to oak-hickory was well shown in the discussion of hunting yields (p. 63). The fact that mixed woods may approach the best oak-hickory in squirrel production is a clue to management on the better soils of the state.

Lowland Squirrel Range

There has been less quantitative work done in lowland habitats than in any other type of Michigan squirrel range. Traps in the river bottom at Allegan were scattered, and figures obtained there could not be interpreted in terms of squirrels per acre. In spite of this lack of exact information, field observations alone are sufficient to show that well-mixed riverbottom timber is good fox squirrel habitat. Lowland woods at the Swan Creek station are well provided with natural dens, and the animals make good use of them in both summer and winter. The borderline between upland oaks and floodplain forest appeared to be especially favorable to squirrels, probably due to a prevalence of dens and the large variety of food presented by so many different kinds of trees. In 1942, Baumgras (12) observed that spring floods caused many squirrels to move from the river floodplain into the oak uplands.

Well-mixed riverbottom, consisting of ash, elm, red maple, butternut, swamp white oak, sycamore, and such borderline species as

Fig. 28. Lowlands occupied by a pure stand of soft maple or elm probably are the state's poorest fox squirrel habitat.

basswood, red oak, beech, and walnut, probably is as productive as some of the better upland habitats. There is little doubt that it is the best of the lowland types. On sand plains there is occasionally a wet phase consisting of swamp white and pin oaks which probably is comparable to scrub oak as squirrel range. On drained swamp-lands pure stands of elm, red maple, or silver maple are occasionally found. These types appear to be more barren of squirrels than any other kind of southern Michigan woodland. They are almost devoid of any staple winter foods and are habitable for fox squirrels only where they border corn land or other tree associations.

In a heavily-grazed, 88-acre, open stand of lowland woods at the Prairie Farm in Saginaw County, only 5 fox squirrels were trapped by Charles Shick in 25 days during the spring of 1941. The woods, which was bordered on two sides by farmland, consisted for the most part of elm, ash, soft maple, and basswood. Even this tract probably is better than the pure stands of elm or soft maple previously mentioned.

In some parts of Michigan, river and stream bottoms represent the most continuous stands of remaining timber, and they furnish important hunting territory. Where such woodlands adjoin farms, constructive management practices may aid the production of a large squirrel crop.

Seasonal Population Changes

If the number of squirrels in a given area remained stable from year to year, each winter's breeding stock would be the same. That breeding stock would expand into a larger summer population which would be reduced again, through mortality, to the yearly minimum in the following spring. The minimum yearly numbers are reached just before the first young of the season begin running about and take their place in the population—about the middle of May. It is desirable for management purposes to interpret census figures obtained at any time of year in terms of hunting yields. If the field worker has a sufficient familiarity with the normal annual population fluctuation among squirrels, the failure of the animals to maintain a productive schedule in an area should be apparent from a census taken at nearly any season.

The "breeding potential"[9] of fox squirrels is such that a spring stock, with the sexes equal in number, should theoretically somewhat more than triple itself by late summer. How this calculation was made is discussed in the next chapter. As would be expected, the species does not attain the theoretical late summer maximum because of mortality among both adults and young. Seasonal figures on sample areas for 8 or 10 years probably will be necessary before it is possible to determine the amount of this mortality and the precise number of fall squirrels to be expected in a normal year from a breeding stock of a given size. However, it is instructive and useful to do the best we can with what is now available.

Squirrel population figures from the two experiment stations show clearly that there is a considerable variation in the productivity of breeding stocks from one year to the next. While a population is on the upgrade, a greater number of young necessarily survive than when numbers are in a year-to-year decline. The 1942 breeding reserve at Rose Lake probably about tripled its numbers by fall, but this evidently was an exceptionally favorable year. In the average year the late summer population probably is about two and one-half times the breeding stock.

As a theoretical example, 50 adult fox squirrels in late winter could *potentially* increase to about 160 animals by fall. However, there would be some mortality among adults and a correspondingly greater loss of young. It is likely that in an average year the maximum numbers reached by late summer would be nearer 130. The hypothetical population curves in Chapter 16 (p. 339) give an estimate of seasonal fluctuations in an unchanging population under hunted and non-hunted conditions.

Judging from present evidence, this is roughly what happens to Michigan's fox squirrels in an ordinary year:

Natural mortalities ....one-third
The annual kill ....one-third
Preserved for breeding ......one-third

This is calculated on a basis of the *potential* maximum population of free-living animals. Since this potential maximum is not reached because of losses among breeders and young in the nest (or unborn) these are charged to natural mortality.

[9]The theoretical capacity of a species to reproduce is sometimes called its breeding potential or biotic potential.

The question arises: If we are not yet sure of such figures, if we are fairly certain that they contain inaccuracies which will need to be corrected as more information becomes available, then why should they be stressed at present?

It is the method we are emphasizing, not the figures.

Even though some of the samples are small, they are the best available, and should be used because there are decisions on regulations, etc. to be made now. Speculations as to the meaning of insufficient data are of value so long as we are ready to accept future truths whether they refute or confirm. There is no doubt whatsoever that the greatest value of the work of the past few years is in the demonstration of *a technique by which our game problems can be solved.*

Fluctuations from Year to Year

One of the earliest indications of a regular fluctuation in the numbers of squirrels was given by Robert Kennicott in 1856 (64) who quoted P. R. Hoy of Racine, Wisconsin. Dr. Hoy observed that in his region the migrations of gray squirrels came at about 5-year intervals. These migrations are generally thought to be a means of relieving overpopulation in that species, and early observers reported that a migration would be preceded by a "high" and followed by a "low" in numbers.

Fox squirrels have seldom been observed in mass movements similar to those of the gray, which was known in early days as the "migratory squirrel." It is probable that in the former species overpopulation is prevented by periodic "die-offs" when certain combinations of unfavorable circumstances occur. As examples, we have the scabies epidemic (and whatever went with it) in the winter of 1936-37 at the Kellogg Farm; also the mast failure and malnutrition which evidently caused a drop in population at Swan Creek in the winter of 1940. Severe winters and summer drouths have been known to have like effects. (44, 95).

From a study of woodlot populations, inquiries among hunters, and information on the annual kill, Baumgartner (11) concluded that Ohio fox squirrels ordinarily fluctuate "in an irregular cycle of from 4½ to 6 years." After evaluating the information available in Missouri, Terrill (95) concluded that, "As yet there is no indication that the species is cyclic."

From information now at hand a "cycle" cannot be demonstrated for Michigan fox squirrels. We probably are not justified in applying this term to fluctuations in numbers until populations have been followed through several "ups and downs" and the period has been found to have a fairly high degree of uniformity. Based principally upon data from local sources, the trends in Michigan fox squirrel numbers have been: fairly high in 1935 and down in 1936 (Kellogg Farm), a progressive increase to 1940 (Swan Creek), lower in 1941 (state kill records), and an unprecedented high in 1942 (Rose Lake, Swan Creek). These indications are not sufficiently complete to justify conclusions as to a fox squirrel cycle, but the state kill records can be depended upon to show such trends if they appear.

Summary of Chapter Four

Studies made on sample areas confirm the evidence of kill records that mature oak-hickory woodland is the best habitat for fox squirrels in Michigan.

Where beech and maple are well mixed with oaks and other species, this forest association probably approaches oak-hickory in productivity, and such types are better than relatively pure stands of beech or beech-maple.

In years of high mast production the scrub oaks found on dry sandy soils constitute favorable range for fox squirrels, and a succession of such years permits numbers to build up to a high level. However, severe food scarcities are likely to occur in the oaks with a resulting decimation of the population. This is particularly true in the north where winters are severe.

Riverbottom woodland, consisting of a good variety of tree species, is a productive habitat; but pure stands of elm or maple, such as sometimes occur on former swamplands or lake bottoms, are little used by the fox squirrel.

Under ideal conditions a fall population of 3 or more fox squirrels to the wooded acre may be attained locally, but it is likely that over any extensive area 2 animals per acre is seldom exceeded.

Under average conditions late summer (maximum) numbers can be expected to be about two and one-half times the breeding stock. Present indications are that on the average about one-third of the potential yearly population of fox squirrels are taken by natural mortality factors, one-third constitute the hunter's bag, and one-third are preserved as breeding stock.

Fox squirrels progressively increased in Michigan from 1937 through 1940. The species decreased in 1941, and reached a new "high" in 1942.

Chapter 5

THE CROP IN THE MAKING

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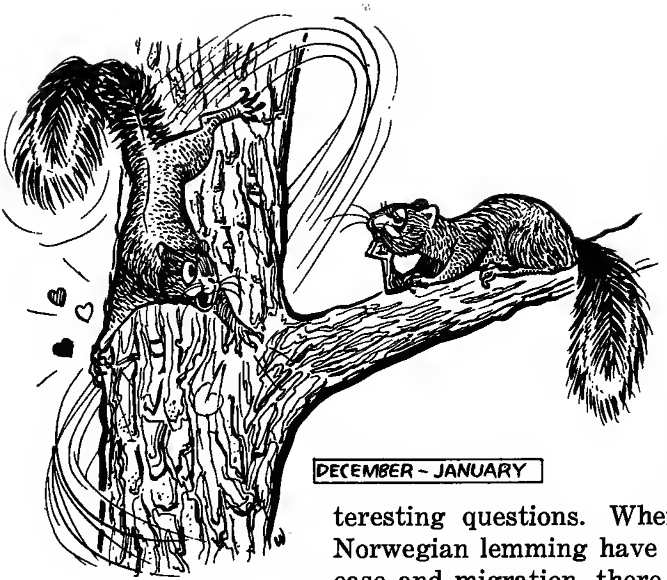
THE CROP IN THE MAKING

All business men who rear domestic stock on a commercial basis, the poultryman, the cattleman, the fur-breeder, know what to expect in the way of annual increase from the animals with which they are working. It is no less important to the wild-life manager to know everything possible about yearly production in wild species and the effects of various factors in modifying that production. His knowledge of a given animal should tell him what percentage of the population, under given conditions, consists of breeding females; how many litters of how many young the average female produces; how long it takes the latest juveniles to achieve independence and be ready for hunting; how large a hunting-season population will result from a breeding stock of a given size—and hence what percent of the population should be shot and how many left as a breeding reserve. Many, if not all, of these quantities are likely to vary with the type of habitat, the particular year, and the numerical status of the species.

What the Books do not Tell

Before the fox squirrel had been intensively studied, that is before 1935, a statement of its known breeding habits would have read something like this: They breed early in the year, in January and February, and it is said that there is a second litter in the summer. The usual number of young is three, and ordinarily they are brought forth in a hollow tree.

That is a good start on what we want to know, but practical management brings up other questions requiring more details. For instance, if there is a summer litter, is our present shooting season too early? Do these summer young breed in January when only a few months old? And if not, when do they breed and what effect does this habit have on the total increase of the breeding stock? If all females do not have two litters, what is the average? If there are less than two litters and only three young per brood, how many of these few young normally survive to fall and how many can we safely shoot? Is the production of young as great in a poor



mast year as in a good one? Since squirrels breed at the season of scarcity (midwinter), does fall shooting reduce food competition and thus favor the production of next year's game crop?

Habits of species related to the fox squirrel bring up other interesting questions. When the numbers of the Norwegian lemming have been decimated by disease and migration, there is an increase in litter size and the number of litters produced, a condition existing during the rise in the cycle (24). Fecundity declines when populations are declining. The same observation has been made on certain other mice and ground squirrels (1, 32, 52, 59). King found some evidence of a correlation of clutch size with the stage of the cycle in ruffed grouse (65).

Does the fox squirrel produce less young when it is abundant, and vice versa? Would a yearly determination of brood size, perhaps, help to foretell a scarcity of game? These and other points of interest need further illumination before the game manager will know just what he can and cannot do. The work at Swan Creek and Rose Lake has not answered all of these questions, but it has added considerably to our 1935 information.

Breeding Season

In the six years from 1937 through 1942, enough records were secured to show that in normal times fox squirrels begin breeding in late December and early January (7, 75). Breeding probably reaches its height in the third week of January and declines to a low level by late February. There is a small amount of breeding in March, April and May. In May and June mating activity increases, and then tapers off in July.

The gestation period of fox squirrels has not been accurately determined, but evidence agrees with the supposition that it is near 45 days, as in the gray squirrel (86). Some litters are born in Feb-

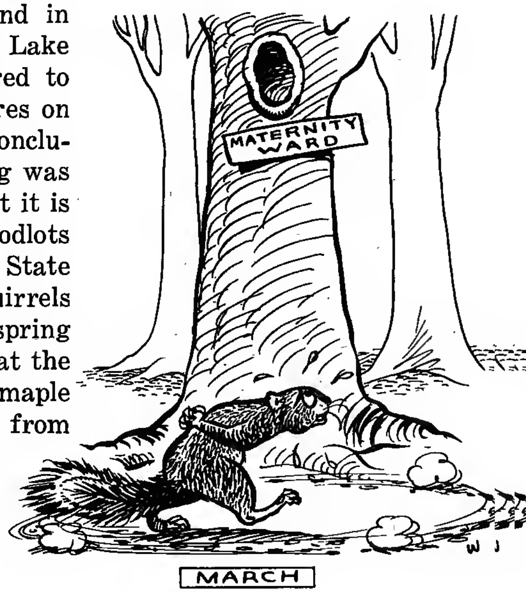
ruary, the earliest recorded being a brood about a week old found in the nest on the 19th of that month (7). Evidently the second week in March is the most common time of birth, with another peak coming in July. There is no doubt that in this latitude some squirrels are born every month from February through September.

Breeding modified by food shortage

During the period in which most of this information was obtained, fox squirrels were increasing in Michigan. But, as was pointed out in Chapter 4, in 1941 at Swan Creek there developed a severe food shortage accompanied by a population decline (p. 89). During late winter and spring Montgomery examined 208 natural nests and dens, 50 wood duck nest boxes, 25 raccoon nest boxes, and 20 artificial squirrel dens without finding a single litter of young. Moreover, among 52 female fox squirrels handled at the station between March and June, only one was pregnant (77). In the similar period of 1940, 139 females were handled, of which 18 were pregnant and 94 lactating (suckling young) at the time they were caught. There is no question that squirrels in the Allegan "oak grubs" produced only a small percentage of the normal number of young in the spring of 1941.

Effect of habitat

This introduces an excellent example of how habitats differ in their production of wildlife. The situation in the Allegan County scrub oaks was much different from that found in farmland woodlots. At the Rose Lake experiment station breeding appeared to be somewhat later than usual (figures on broods were too small to prove it conclusively) and the crop of spring young was smaller than in "normal" years. But it is significant that in oak-hickory woodlots of that area and in the Michigan State College beech-maple woodlots, squirrels did breed and produce young in the spring of 1941. Montgomery also found that the animals were breeding in two beech-maple woodlots in farmland about 20 miles from the Swan Creek station.



There is some satisfaction in finding a well-defined factor to which a population change can be ascribed. Too often there is a confusing complex of causes. There are still plenty of mysteries to be unraveled, but it appears certain that food supplies constitute an important key to the fluctuations of squirrel numbers. Subsequent observations showed that if 1940 had been followed by another poor mast year, the Swan Creek squirrel population would have hit "bottom." As it turned out, the situation was saved by a good mast crop in 1941, and the animals showed a surprising adaptability in compensating for the lack of a 1940 spring generation. The increase in breeding during that summer and early breeding by juveniles in 1942 will be referred to in the sections following.

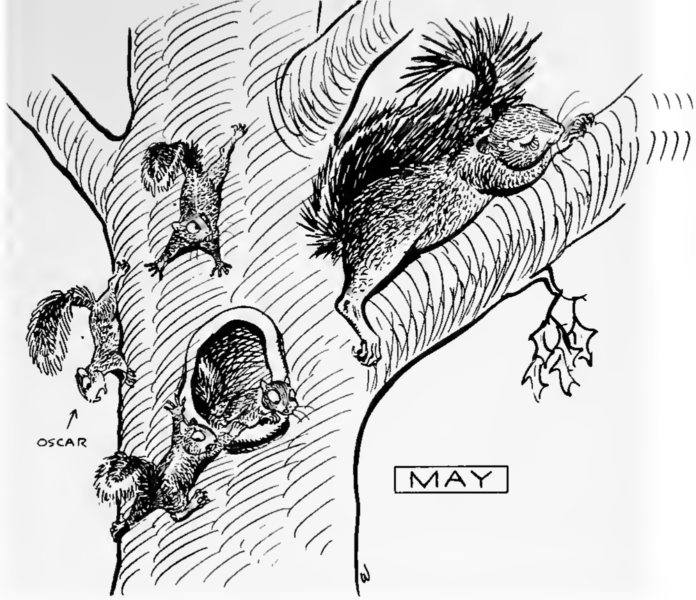
It is interesting to speculate how some of the trusted cure-alls of the past could have affected the Swan Creek situation if there had been a 1941 mast shortage and events had gone against the squirrels. This frequently happens farther north. A closed season would only have increased the already-acute winter food competition. Sanctuaries would have done the same. How about predator control? What would a big job of restocking have done? Our line of thought is always to produce, to add to the numbers of animals. And singularly enough, the situation called for just the opposite—a reduction. The carrying capacity of the habitat declined so that populations had to decline (temporarily) with it. The best measure that could have been employed would have been a bigger and better shooting season in 1940 so that more animals would have been killed instead of starving, and the remainder could have survived in better condition.

APRIL

It is obvious that the only way to determine the reason for game scarcities and to remedy them is to have trained men in the field studying problems as they come up and preparing to anticipate them in the future. How the scrub-oak food situation can be dealt with is discussed elsewhere (p. 291).

A summary statement on the breeding season, would be that mating is ordinarily most intensive during January and February and again in May and June. But in certain years, in certain habitats, factors intervene to alter this.

Number of Young



At first consideration it might seem possible to collect an adequate sample of gravid females of any given species, dissect out the embryos, determine once for all the average litter size for that animal, and file away the information for future use. But the farther the biologist goes into the facts of life, the less he is inclined to believe that anything is stable, or to accept his findings at their face value. Sooner or later, nearly any flat statement he makes needs some qualification. Thus it is easy to say that the fox squirrel has three young at a birth and produces two litters per season. But to anyone well acquainted with animals this is not completely satisfactory.

For instance, it is true of the skunk (4, 86), the meadow mouse (52), and probably of other species that young females produce smaller litters than old animals. Is this also the case with squirrels? As was pointed out before, among some rodents both the young per litter and the number of litters per year vary with the stage of the population cycle. We have already seen how a dearth of food may cause a near cessation of breeding in the fox squirrel. Is a decline in reproductive rate (caused by what?) the mechanism, or one of them, by which numbers are reduced when widespread scarcities occur?

Young per litter

From 1937 to 1939, Baumgartner (11) obtained 92 records of fox squirrel litters in Ohio and found that the yearly averages per litter were 3.94, 3.06, and 2.58 respectively. Table 5 summarizes the fox squirrel brood records obtained in Michigan by various investigators from 1937 through 1942. These include counts of embryos, young in the nest, and placental sites[10] in females which

[10]A technique used first by Montgomery (75) in 1940 and in all studies in 1941. For some time after parturition (birth) dark congested areas in the uterus show the former position of embryos.

had already borne young. Of course, the higher the number of records secured in one year, the more accurate the average will be. The numbers of litters handled in 1937 and 1938 were obviously too small to give reliable yearly averages. The figures for 1939 and 1940 from Allegan County may indicate larger broods in 1940, but they are still too small to permit definite conclusions as to whether there is a yearly variation in brood size.

A total of 170 brood records over a period of five years shows that the litters varied from 1 to 6 with an average of 3. This average is a reliable basis for calculating the reproductive rate.

TABLE 5

Litter Size in Michigan Fox Squirrels

Year	*County*	*Size distribution of litters* 1	2	3	4	5	6	*Total litters*	*Total young*	*Av. young*
1937	Kalamazoo		2	6	1			9	26	2.88
1938	Allegan		2	1	1			4	11	2.75
1939	Allegan	1	7	24	5	1		38	112	2.95
1940	Allegan	2	9	30	15	3		59	185	3.13
	Clinton	1	1	3	3	1		9	29	3.22
	Barry			1				1	3	3
1941	Clinton		3	1				4	9	2.25
	Ingham		3	3				6	15	2.5
	Allegan	1	4	4	3	2		14	43	3.07
1942	Clinton		3	5	2			10	29	2.9
	Allegan	1	4	4	5	1	1	16	52	3.25
Totals		6	38	82	35	8	1	170	514	3.02

Litters per year

Production by summer yearling females: From the appearance of young squirrels in both spring and summer, observers concluded a hundred years ago that a female fox squrrel produced two litters per year. This was ascertained to be true of some individuals when certain marked animals on the Swan Creek area were found to have bred twice in 1938. Since then it has been recorded in numerous cases. In this same work, however, it was found that in most years squirrels of the summer litter did not come into breeding condition in late winter, but bred for the first time in late spring or summer. Thus this generation could yield only one litter of offspring in their first year.

Until 1942, no examples had been found of summer juveniles coming into breeding condition in the late winter period. However, that year proved exceptional, for half a dozen such records were secured by Baumgras (12) at Swan Creek. It will be recalled that in the scrub oaks there was no spring generation in 1941, but there was an exceptionally large summer generation, and Baumgras marked a number of these young. This provided a good opportunity to follow the history of such animals, and it was established that many of the females were in full breeding condition as early as January and February. Males were much slower in developing. Although exceptional situations may develop at times, judging from what is now known, summer juveniles usually breed in May or June and produce only one litter in their first year.

Production by spring yearlings: After the work was well under way in 1938, it became evident that there were some females which bred in spring but not in summer; and these animals also accounted for only one brood of young. It has been fairly well

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established that in most years fox squirrels come to sexual maturity at 10 or 11 months of age, and that they do so whether they are born in late winter, summer, or between times. There are also strong indications that yearlings breeding for the first time in January, February, and March form the bulk of the group of females which produce no summer litter. Some old animals, in poor condition from mange or other causes, also breed but once. It may be that the most vigorous yearlings do have two broods their first year, and there are some cases in which this probably happened, but evidence is scant. The reason is that after a female has bred once, its age cannot be determined by any known method, and unless the animal was previously marked at a time when age could be established, the record is indefinite. All squirrels of definitely known age which bore two litters in the same year were old individuals.

Seasonal sequence: Through the year the picture is somewhat as follows: In December (and in a few exceptional cases earlier) some old males are in full breeding condition. Somewhat later, perhaps two weeks, the earliest females are ready to breed, and first matings occur in late December. By mid-January practically all old males and most yearlings are fully developed, and the height of the mating comes in late January. Some animals develop late and breed during February, March, and April. These are probably young born in late spring the year before and, possibly, old females

which lost their first young early in the year. In April and May, yearling squirrels born in June, July, and August of the previous year are coming into condition to breed. Probably most of these matings take place in May and June, although some are as late as August. During this same period, some females are producing their second litters of the year.

The winter breeding population of squirrels is composed of animals belonging principally to three age groups. There are "old" individuals of two years or more, and yearlings that were born in the preceding spring and summer, respectively. Old squirrels commonly bear a spring and a summer litter and have an average annual production of six young. Spring yearlings breed in late winter when about 11 months old, but most of them probably do not breed again in summer. Summer yearlings are not ordinarily mature in the winter period, and in most years they breed in late spring or summer. Thus females of the two yearling generations average 3 young per year or possibly slightly more. It may be found in the future that a significant portion of the spring yearlings do have a second litter in summer, in which case this figure on yearly production will need to be revised upward.

This information was secured largely as a result of handling some 1500 squirrels about 2500 times at the Swan Creek and Rose Lake stations from 1937 through 1942. We have already observed that habits differ from year to year, and although this information will serve well for the present, there is no reason to believe we have the whole story yet.

Compensatory breeding

What happened among Swan Creek fox squirrels from 1940 to 1942 probably is of fundamental significance and should not be passed over lightly. We appear to have here an excellent example of the resilience of an animal population in compensating for severe losses in number. In June 1941, the Allegan oak woods

contained only old squirrels. The usual large spring generation was entirely absent. But although no females were known to have produced a spring litter of young, practically all of them bore young in the summer—an unusual condition. Thus, by fall the population of squirrels at Swan Creek, from point of numbers, approached that of the year before. There was the noticeable difference, however, that partly-grown animals were much more conspicuous in the fall kill than in most hunting seasons. Since the same observation (in a lesser degree) was made at Rose Lake and in the squirrels examined on eastern Michigan road blockades, it seems evident that all over the state the effect of the short mast crop and the increased breeding in the following summer were much the same.

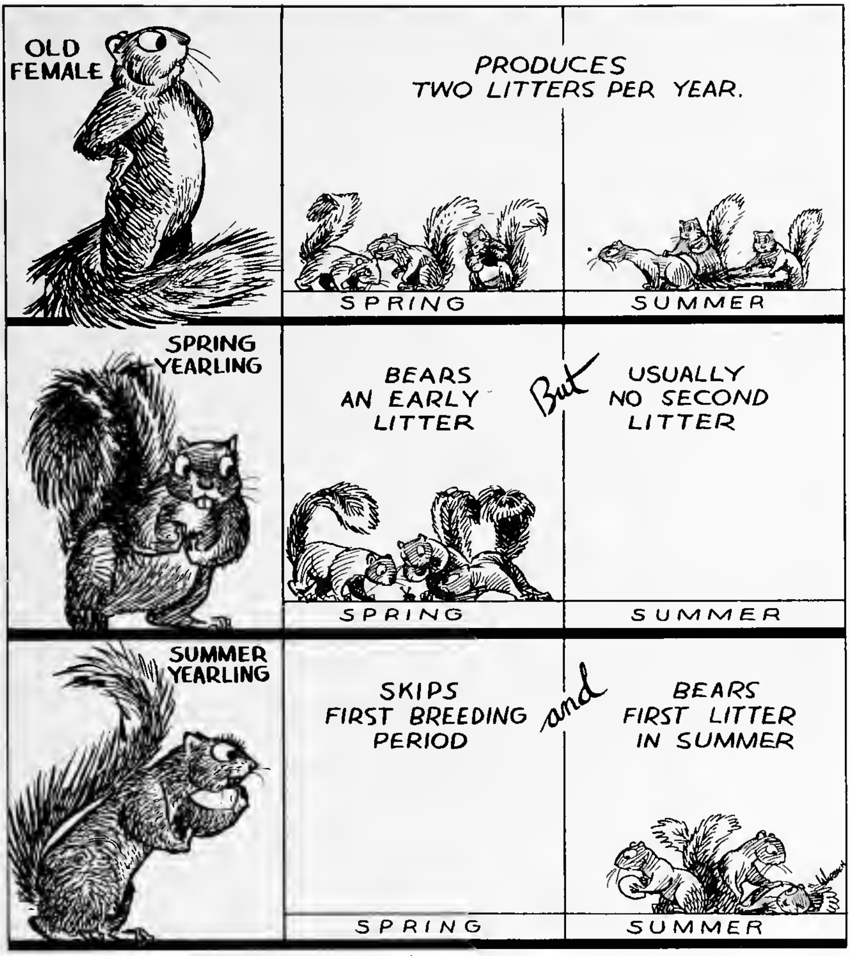
What was evidently another compensatory reaction was observed in the spring of 1942. With no spring yearlings in the population, a small production of litters would have been expected. But nearly every female handled by Baumgras was breeding—4 or 5 months early for the summer yearlings.

These phenomena have a marked similarity to a case cited by Errington (37): In one side of a marsh, where their numbers had been seriously reduced, muskrats continued to breed later in the season and produced many more young than in another portion of the area where they had not been subject to so great reduction. As another example, several species of wild mice were breeding to an exceptional extent at Rose Lake in midwinter of 1941. The meadow mouse population had been very low the summer before. Was this a reaction to lowered numbers? We will doubtless find many such responses as the dynamics of animal populations become better known. Such adaptability has enabled some species to survive when others became extinct. The idea certainly is to be kept in mind in dealing with game if we are to get the most for our money.

Fecundity of the Fox Squirrel

Average productivity of females

The foregoing data on age groups show that female fox squirrels do not average two litters per year. The average is more than one and less than two. It will be shown that the normal fall age ratio is roughly two-thirds young of the year, and one-third old animals. Thus, approximately one-third of the breeding females can be



The winter breeding population of squirrels is composed of animals belonging to three age groups. There are "old" individuals of 2 years or more, and there are yearlings that were born in spring and summer, respectively, of the year before. Old squirrels commonly bear a spring and a summer litter and have an average annual production of 6 young. Spring yearlings breed in late winter when about 11 months old, but evidently most of them do not breed a second time. Summer yearlings are not yet mature in the late winter period, and ordinarily they do not breed until spring or summer. The normal fall age ratio probably is about 60 percent juveniles and 40 percent old animals. For this reason it would be expected that one out of three females would produce 6 young, and this would bring the average production per female in the population to near 4 young per year.

expected to be more than a year old and bear two litters. If all yearlings produced one litter, this would give an average production of four young per female. That is the figure used in most of our computations. In some years average production may be slightly more than this, since a few cases of abnormally early breeding by summer juveniles are now known, and it is possible that some yearlings breed twice their first year.

Yearly variations: Figures from the Allegan area indicate a marked variation from one year to another in the size of the new generation of squirrels. How much of this is an actual difference in litter production and how much is a difference in survival rate is not always clear. In 1940 a large breeding population resulted in a small proportion of young of the year chiefly because of poor survival of the juveniles. In 1941 the animals produced no young in the spring because they were in no condition to breed. But in summer they far exceeded the usual expectancy for that time of year. A population consisting only of old squirrels and juveniles of the previous summer gave rise to an exceptionally large crop in 1942. Parallels to most of these observations were made at Rose Lake.

The effect of environmental conditions on fecundity is a matter of great significance. It has been quite evident that favorable conditions for bearing and rearing mean a high squirrel population, almost without regard to the numbers of breeders. Small breeding stocks have been consistently more productive, proportionally, than large ones. The evidence is convincing that in creating large game yields attention to range conditions is the important thing, and that a drastic fall reduction of the population will, in itself, help to create those conditions necessary for maximum breeding and survival of young.

Comparison with other species: Comparing the fox squirrel's annual production of four young per female with other common game animals brings out an important point: This creature has fewer young than any of our other small game species except the raccoon. Table 6 gives the approximate number of hatched or newborn offspring which a typical pheasant, quail, rabbit, skunk, and raccoon produce in a season. If a cottontail must turn out 15 or more in a year to replace losses during the time between breeding seasons, a pheasant 10, and a skunk 5, it must mean that the mortality rate in these species is proportionately higher

than in the fox squirrel. From this it can be deduced that the squirrel has comparatively few enemies and takes good care of its young. Field evidence corroborates this.

TABLE 6

Production of Young in the Fox Squirrel Compared with Other Common Game Animals

Species	*Broods per year*	*Young per brood*	*Young per female*
Pheasant[11]	1	10	10
Quail[12]	1	13	13
Rabbit	3+	5+	15+
Skunk	1	5+	5+
Raccoon	—1[13]	4	3
Fox Squirrel	1+	3	4

Development of the Young

Fox squirrels bring forth their broods in either leaf nests or hollow trees. In Michigan studies more have been found in hollows than in nests, and it is fairly certain that the animals prefer the safety of an old den tree if such is available. In the Allegan area one female is known to have borne three litters in the same hollow in 1939 and 1940. In general, this species has a long period of development during which broods must be cared for by the parents. This would be expected in an animal producing so few young. In species with a high rate of increase the period of development is short, and the young are independent at a relatively early age. Practically all of the following data are from the Allegan studies (7, 12, 75).

Condition at birth and early growth

Newborn fox squirrels weigh about half an ounce (13 to 17 grams) ; they are devoid of hair and practically helpless. A squirrel's claws are the only parts of the animal which appear well-developed at birth (fig. 29). The vibrissae on the chin and nose are visible,

[11]Estimate of the number of hatched young produced by a breeding female based upon the work of English (33) on the pheasant in Michigan and Hamerstrom (51) in Iowa.

[12]Estimate based upon the work of Stoddard (91) in Georgia.

[13]Only about 50 percent of Michigan raccoons breed as yearlings (Stuewer, 94) ; thus the average per female in the population is less than one litter.

Fig. 29. A litter 2 days old. They are blind and hairless except for the vibrissae. The nails are the only well developed parts.

and they become more prominent each day. The first hair appears on the back of the head and shoulders and begins to show by the time they are a week old (fig. 30), at which time they have doubled their weight. At three weeks the weight has increased to about 2 ounces and the upper parts are well covered with dark hair beginning to turn brown on the tail and around the eyes and mouth. In the third week the ears open and the lower incisor teeth appear, but the eyes are still closed. By this time the claws are long and quite sharp. The eyes of young captive fox squirrels do not open until the fifth week (fig. 31) when the animals weigh 2.5 to 3 ounces. At this time hair is appearing on the under surface of the tail, which is the last part to be furred. It is possible that wild squirrels develop somewhat more rapidly than captive animals. This is indicated by two weights which Montgomery obtained on a wild litter in 1940. This is one of a few instances in which such a litter has been handled twice, as the mother usually moves them when they are disturbed.

Fig. 30. Approximately 9 days old (one-inch grid). Hair is coming in on the upper portion of the body.

Fig. 31. The eyes of this captive specimen have just opened. It is 33 days old.

The rate of development undoubtedly is conditioned by the number of animals in a litter. The growth curve of three captive juveniles in 1939 definitely broke and leveled off when two more young were given to the mother and the litter became five. Using some other captives, in 1941, Baumgras found an average daily weight increase of 2.93 grams per squirrel in litters of 3 and 5.25 grams in a litter of one (12).

Parental care

Soon after their eyes open, young fox squirrels begin to climb about inside their nesting hollow, and they probably first venture into the daylight at 7 or 8 weeks of age. Juveniles of this species evidently do not leave the home den tree to forage on the ground much before they are 3 months old, at which time they usually weigh 10 to 14 ounces. Individuals weighing less than 9 ounces are seldom taken in a box trap, although a conspicuous exception to this is a brood of 6-ounce squirrels caught at Rose Lake. One of these was taken in a trap with the mother. There are no specific individual records to prove how old they are when they begin running about, but it can be deduced from trapping results. The earliest births during a 3-year period at Allegan were in mid-February, and the earliest records of juveniles taken in box traps came in the middle of May. Most young animals were born in March, and during June there was a big increase in the number of small juveniles taken.

A good clue to the schedule of an early litter was obtained from observations on a brood in the backyard of P. S. Lovejoy in Ann

Arbor in 1941. In late January, Mr. Lovejoy watched a squirrel carrying white oak leaves into a den, evidently preparing it for impending events. When the den was examined in April, the female would not come out and appeared to be guarding her young. About the 20th of April the young squirrels first began to come out of the den. By the middle of May they were commonly seen in the tree but had not yet ventured onto the ground. Up to this time they had been seen chewing bark and buds, but probably were deriving their nourishment from the mother. They were first seen on the ground in the third week of May.

These observations indicate that fox squirrels are under parental care for at least three months. This species has not been known to bring food to its young, so they must depend upon milk until old enough to travel about. For management purposes, the most important thing is to know that they become self-sustaining in the fourth month.

Family Relations

Not much is known of the sociology of fox squirrels. This results largely from the fact that they are so difficult to breed in confinement. But a number of observations have been made which sketch in a rough sort of picture that is better than none.

Fig. 32. Squirrel pen at the Swan Creek Wildlife Experiment Station. It is 6′ x 6′ x 10′ and is covered (including floor) with inch-mesh fox netting.

Fig. 33. At about eight weeks of age—early May for most litters—young fox squirrels are climbing about the home den tree. Probably most are about 10 weeks of age before they venture far on the ground.

Pairing

In late fall and early winter it is not uncommon to see groups of three or more squirrels chasing about in the trees in what appears to be pre-mating activity. This probably culminates in the pairing of the female with one particular male. There is evidence that one male may occupy the same nest with the female during the time of breeding, and remain in close proximity during the rearing of young in one or both breeding seasons.

In the fall of 1940 each of four raccoon den boxes at Swan Creek was found to contain two squirrels, and in one case these were identified as an adult male and female. Another record was obtained when a pair of adults were collected from the same leaf nest

on December 17 (75). At other times of year, when more than one squirrel has been found in the same nest, there was evidence that they were groups of subadult animals, sometimes with an old female. There have been numerous cases where an adult male squirrel remained close by a female with a litter of young, giving the impression that the animals had paired earlier and the male was being kept at a distance until needed again. It has been observed that a female commonly keeps all other squirrels out of the nest where her young are located. Twice, when a mother squirrel was killed, the nest was immediately occupied by a male. The litter disappeared in one case and in the other the young were partly eaten. Evidently there is good reason for keeping the male parent at a distance.

Dispersal of the young

The length of time a brood of squirrels remains together seems to depend on circumstances. There have been occasional indications that spring broods broke up in June, but for the most part these litters appear to remain in the vicinity of the home nest or den tree until August or September. It is quite possible that a female bearing only one litter, and that in the spring, remains with her young longer than an animal which produces a second brood in June or July. But in summer it is not unusual to catch juvenile animals, evidently from an earlier mating, in the immediate vicinity of a female with a summer litter.

It is in fall, winter, or spring that families of fox squirrels, except for the adult male, have most often been found in the same den. In the half-a-dozen-odd cases of this, all have been sexually dormant summer juveniles, evidently from a late litter. Perhaps the most striking example was found by Montgomery in May, 1940. In one den there were three fully-grown but sexually immature (summer-before) yearlings with an adult female which was lactating. The old animal had a new litter but evidently had paid a visit to the brood with which she had spent the winter. In spring, nonbreeding juveniles of the summer before have several times been found occupying nests near to a female with young, or two or three of the same size and development have been taken in the vicinity of a new family.

Age Groups in the Population

Unquestionably we would be able to deal more efficiently with game species if it were possible to foretell population trends. To some extent it may be possible to do this for such strikingly cyclic animals as the snowshoe hare and the ruffed grouse. In the fox squirrel investigations the possibility of finding some index to impending changes in numbers has been kept constantly in mind. The ratio of young to old animals in the fall kill appears to have particular value in interpreting the impacts of certain environmental phenomena on the population. When more is learned of such things as this, it may well be possible to predict significant events a year or more in advance.

Age determination

When these studies started, we had very little idea of what characters might be used in separating squirrels of different ages at different seasons of the year. There is much progress still to be made in this field, but the methods that have been worked out are sufficiently reliable for most purposes.

Fig. 34. Mastology of a squirrel which has never borne young. In young animals the nipples are minute and barely discernible up until the time of pregnancy, when they begin to pigment and swell (specimen Jan. 15, 1940).

In the hunting season, many juveniles can be separated from old animals by their size. Old squirrels in good condition usually weigh from 1 pound 10 ounces to 2 pounds. Spring juveniles may be expected to weigh 1 pound 5 ounces to 1 pound 10 or 11. Summer juveniles vary from 12 to 15-ounce animals just out of the nest to well-grown individuals of 1-6. It is, of course, not always possible to weigh squirrels, and the weight groups overlap considerably, so that size is a poor criterion in many cases. A better index of age is obtained from an examination of the sexual organs.

Age characters in females

In the fall, a female of the year has undeveloped nipples, which are white like the skin and so small they can be detected only by carefully separating the hair on the belly (fig. 34). They appear as minute slightly-raised "pimples" on the surface. In squirrels which have had a spring but not a summer litter the teats are also much reduced, but there is nearly always a small dot of black pigment in the tip. Females which have suckled a summer litter have large pendulant nipples, conspicuously black at the end, with most of the

Fig. 35. Mastology of lactating female in April (1938). The black pigmentation of the nipples never completely disappears in most specimens. This makes it possible to separate old from young in the fall.

hair worn off around them (fig. 35). Some animals are difficult to place in the proper age group by external examination. An examination of the uterus usually helps, since in virgin females this organ is of smaller caliber than in animals which have borne young, and in the latter the two horns are likely to be unequal in length.

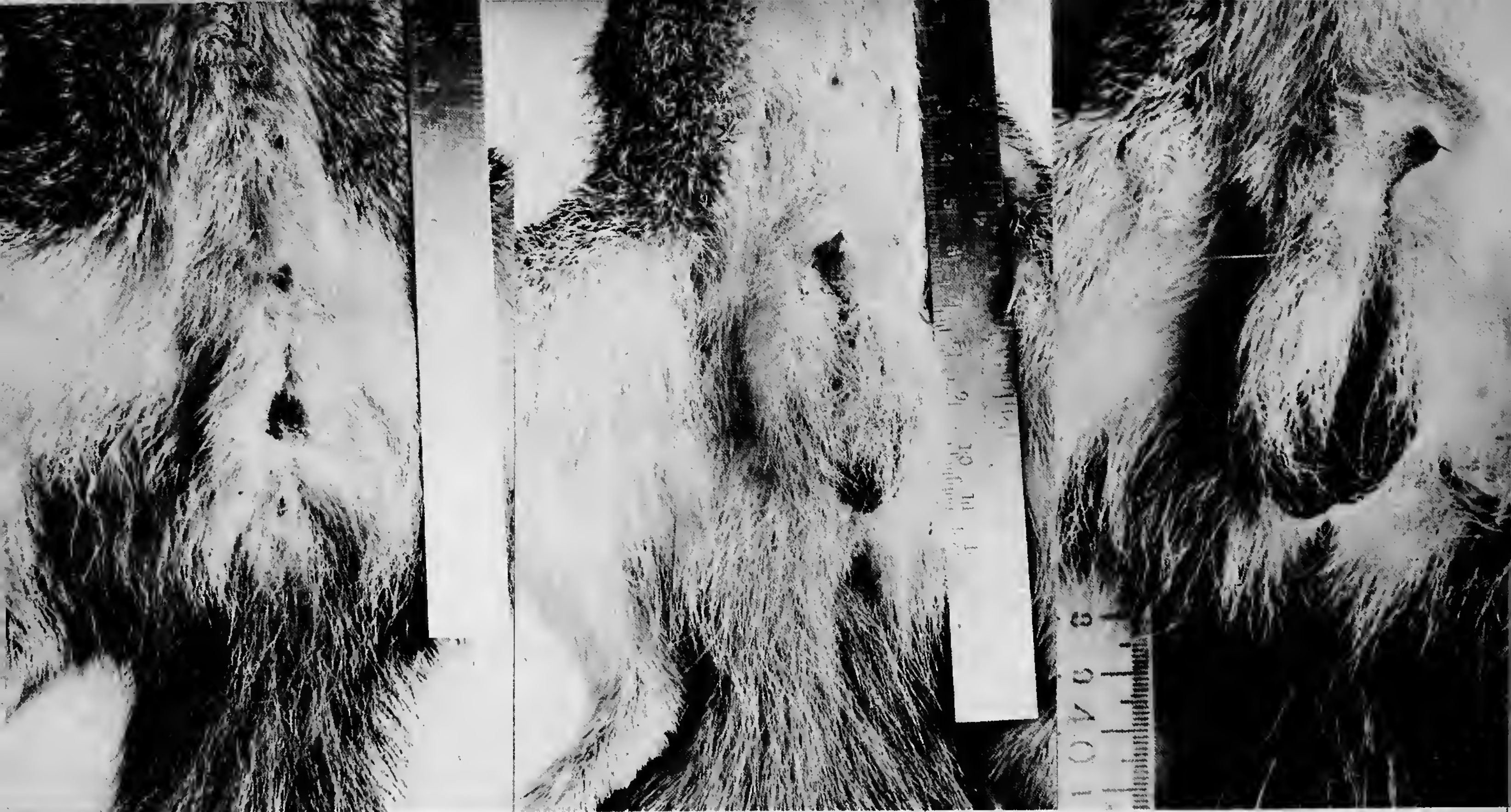
Age characters in males

"Aging" male squirrels is even more difficult. Young animals born early in the year (February and March) have a well-developed scrotum showing a black pigmented patch by July (fig. 36). The testes at that time are about 3/8 inch in length. By October the scrotum of such animals measures 1 to 1¼ inches, and by December it will be fully developed at 1½ to 1¾ inches. During the breeding season, in yearling specimens, the scrotum is usually more heavily furred than in old animals. Old males have the scrotum nearly bare of fur, and black and wrinkled for most of its length. In late winter, when spring yearlings and old males breed, summer juveniles have the testes in the abdomen and the scrotum is entirely undeveloped (fig. 36).[14] These squirrels are at full sexual development in May and June. Since some animals are born every month from February to September, males are found at practically every stage of development in most months of the year.

Age determination of males is complicated by the decline of the testes after breeding. It is probable that in most individuals which come into breeding condition early in the year the testes remain at about their full size until May or June. It is not known whether the animals are capable of breeding during the latter part of this period. But in summer the organs decline in size, and the black wrinkled skin of the scrotum is sloughed off. After this skin is shed, the scrotum is flesh-colored or gray in patches, and a new growth of hair appears. The testicles may be retracted into the abdomen. In this condition an old squirrel can easily be mistaken for a developing juvenile, although the sac is large and loose and quickly becomes pigmented again.

Thus female squirrels are more easily aged than males, and where the animals are handled rapidly, as when game is examined on road blockades, only females are used to obtain age ratios. In all such work some animals must be eliminated as questionable.

[14] It is probable that these undeveloped juveniles have given rise to the stories of young male squirrels emasculated by old males or by red squirrels.



SUMMER YEARLING SPRING YEARLING OLD SQUIRREL

Fig. 36. Scrotal areas of squirrels of the three age groups in February. In summer yearlings the testes are abdominal and the scrotal skin is just beginning to pigment. In the spring yearling the testes are large and the scrotum is pigmented, but it is heavily furred. The old animal has shed most of the fur from the scrotum. The condition of many spring yearlings approaches that of old squirrels, and due to this overlap not all animals can be satisfactorily aged by the use of this character.

Age ratios

According to our calculations of reproductive capacity in the fox squirrel, an average population in an average year should produce approximately 4 young per female. Thus a spring breeding stock of 50 squirrels, half females, should have a potential increase of 100 young, giving a potential fall population of 150 squirrels.[15] If there were no differential mortality, the fall age ratio would be two-thirds young and one-third old animals. It is certain, however, that juvenile animals have a higher mortality rate than old ones, even though the fox squirrel takes good care of its young, and the low fecundity of the species necessitates a high survival rate. Everything considered, it seems logical to expect a fall age ratio, in a year when the population level is not changing, of about 60 percent young of the year.[16]

To what extent this estimate is correct can best be judged by an examination of Table 7. The years 1940 and 1941 were compli-

TABLE 7

Fall Age Ratios of Fox Squirrels in Michigan

				Age ratios	
Year	*Location*	*Source of data*[17]	*Total squirrels examined*	*Number Adult: Juv.*	*Percent Adult: Juv.*
1938	Swan Creek	Trapping	64	21:43	33:67
1939	Swan Creek	Trapping	76	20:56	26:74
1940	Swan Creek	Trapping	122	91:31	75:25
	Rose Lake	Trapping	64	46:18	72:28
		Hunting kill	66	48:18	73:27
1941	Swan Creek	Trapping	59	33:26	56:44
	Rose Lake	Trapping	161	63:98	39:61
		Hunting kill	61	13:48	21:79
1942	Swan Creek	Trapping	29	16:13	55:45
		Hunting kill	36	19:17	53:47
	Rose Lake	Trapping	209	70:139	33:67
		Hunting kill	130	44:86	34:66

[15]Or possibly a few more, as indicated on page 100.

[16]It will be noted that in several places in the text the age ratio has been mentioned as being roughly two-thirds young to one-third adults. This has been true in most of the years upon which significant data were secured. But these were years in which the population was increasing. In an unchanging population, which should be taken as the standard, the proportion of young probably is nearer 60 percent. Such figures are used rather roughly here because the difference between two-thirds and 60 percent is less than the possible error in yearly records and our calculations.

[17]The trapping figures from Swan Creek are for November in 1939 and 1941 and October in 1940 and 1942. The Rose Lake trapping was done approximately from the middle of September to the middle of October each year.

cated by factors to be discussed later, and these can be disregarded for the present. But 1938, 1939 and 1942 were favorable years in which the squirrel population was increasing. Considerable statistical error can be expected because of the small numbers dealt with, but it is evident that populations in these fall seasons comprised about two-thirds young and one-third old squirrels. The most satisfactory numbers handled in any of the years were at Rose Lake in 1942, and these indicate almost exactly the age distribution mentioned.

The age ratios for 1940 and 1941, given in Table 7, and the graphs in figs. 37 and 38, tell a story that is closely tied in with what has been happening in Michigan's fox squirrel population during the past five years. In tracing the sequence of events, a few points already mentioned will be reviewed. In 1938 and 1939 the percentage of young squirrels handled at Swan Creek was high, reaching an indicated 74 percent in November 1939. During this time the species was definitely increasing in the state, which could hardly come about except by high survival among young squirrels. A large population of breeders was brought through the winter of 1939-40 by the excellent mast crop of that fall, and these animals bred normally the following spring. Such conditions also obtained at the Rose Lake experiment station in Clinton County farmland. The graphs show that up to midsummer on both areas the percentage of young squirrels was increasing. However, when a new nut crop should have developed in July and August, the worst mast failure in years occurred. Young squirrels beginning to earn their own living found very little of what to these animals is staple food. This condition evidently was reflected in an altered ratio of old to young in the fall population. At Swan Creek only 25 percent (31 of 122) of the squirrels handled in the traps were adjudged to be young of the year. At Rose Lake 28 percent (18 of 64) of those killed in the hunting season and 27 percent (18 of 66) of the trapped animals were juveniles.

Especially significant information on this situation was secured at Rose Lake where an intensive pre-hunting job of trapping was done. Of 18 juveniles of the year handled in traps, only 7 were in woodlots. The remainder were in open fencerows and outlying situations. Of 46 adults taken, 32 were in woodlots and 14 were in the open. In these figures there is a strong suggestion that juvenile squirrels were being driven by the old animals into less favorable situations where they were subject to a much higher mortality

rate than in woodlots. There is also a possibility that with food so scarce these juveniles were less prudent about venturing into the open for fieldcorn or to garner the small yield of certain fencerow hickories which were more attractive than the completely barren woodlot trees. The logic of the situation is that young squirrels in the open were more available to hunters and natural enemies than the old ones in woodlots. Of course, we do not know the exact mechanism by which the percentage of juveniles in the population was reduced, but all of these indications "add up" in a way that begins to take tangible form. Tabulations for the following year showed no difference in the frequency of young and old squirrels in woodlots and in the open.

In the winter period at Swan Creek, squirrels failed to breed, and young animals began to appear first in July. Thereafter a new mast crop became available, and coincidentally the squirrels compensated for the lack of spring young by producing an unusually large summer generation. By November the proportion of juveniles (all summer juveniles) was up to 44 percent (fig. 37).

At Rose Lake food conditions were better, and fox squirrels produced young in the spring of 1941, but breeding appeared to be later than usual, and litters were difficult to find. June showed an age ratio with only 12 percent juveniles. Summer breeding, as at Swan Creek, was heavy, and summer juveniles were conspicuous in the hunting season kill. Fig. 38 indicates that there were about 67 percent young animals in the population during September and October.

The carrying capacity of the habitat, as determined by food supplies, appears to have been the most important factor in these fluctuations. In the winter of 1939-40 the habitat was capable of supporting a high population, and large numbers of squirrels survived to breed. This unusual breeding reserve should have been capable of expansion in 1940 to a point even above that of the year before; but such multiplication was effective only up to the limits of what the range could carry. When that point was reached (it was much lower in 1940 owing to the poor acorn and nut crop), the weakest animals in the population were to a great extent eliminated. The individuals least fit to survive were the young of the year. The scrub oak habitat at Allegan exhibited more extreme conditions and a more radical fluctuation than the oak-hickory woodlots at Rose Lake.

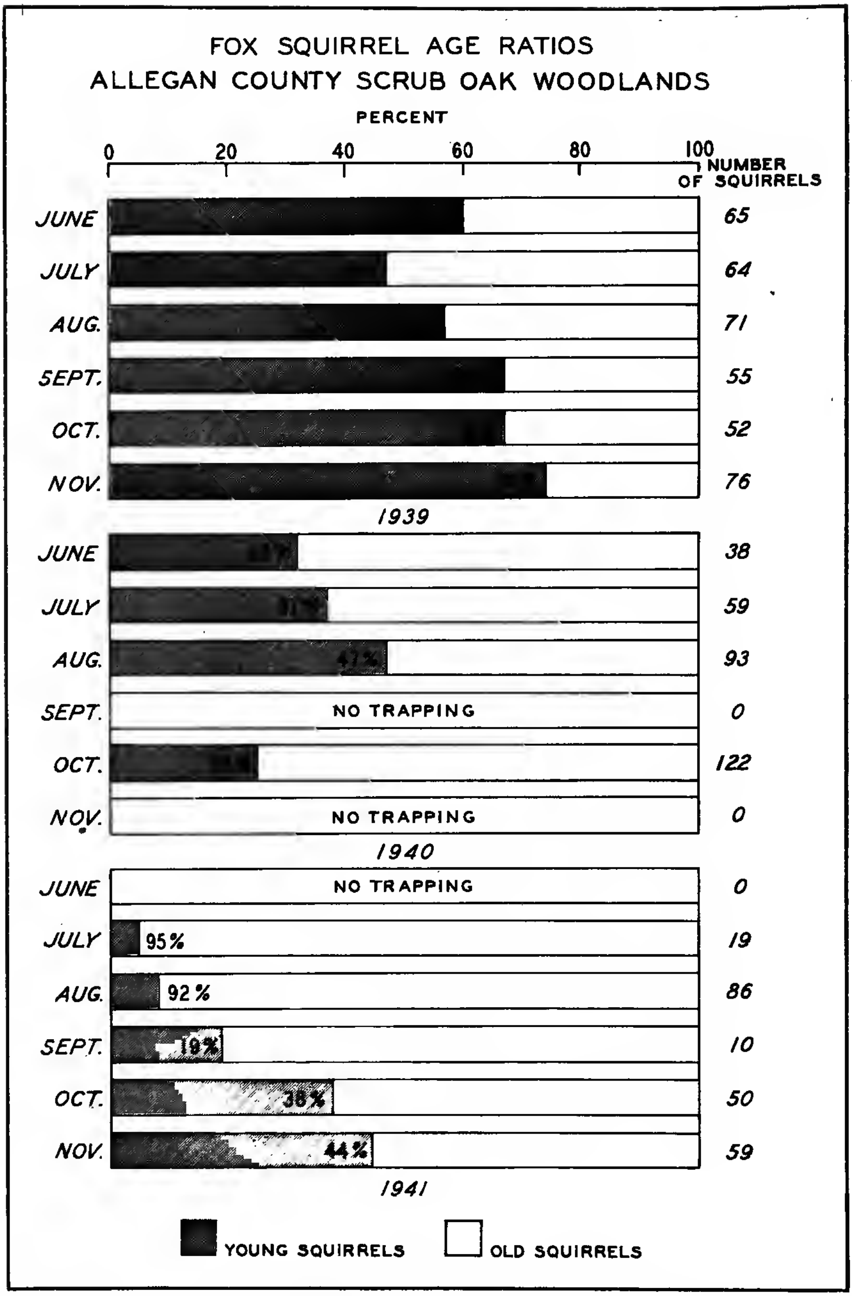
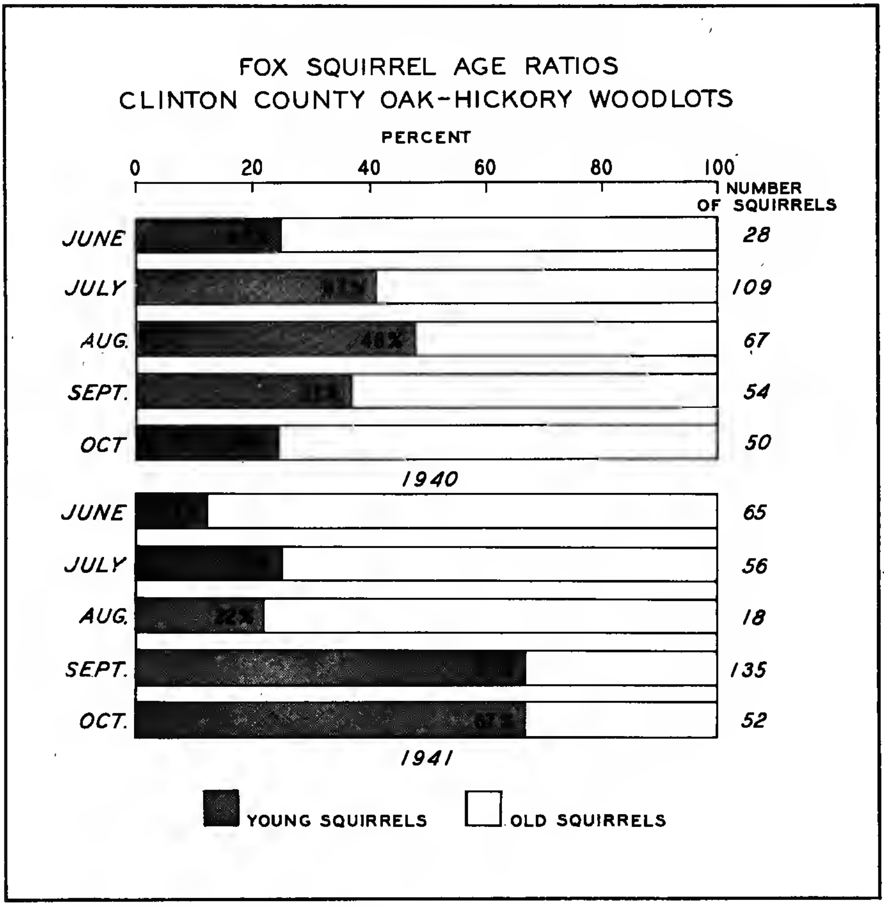


Fig. 37. In the 3-year period 1939-1941, significant changes in the summer and fall ratios of old to young squirrels took place at the Swan Creek Wildlife Experiment Station. The high catch in June 1939 probably is due to a high mobility among first-litter young which are

becoming independent at that time. The proportion of juveniles in the fall was higher than is ordinarily expected (about two-thirds). This may be owing to exceptionally good survival and a consequent increase in numbers over the year before. The unusually large breeding stock of 1940 produced proportionately fewer young than that of the previous year, and from midsummer on, juveniles evidently were reduced by the mast failure and consequent competition with the high population of adults. Many squirrels died during the winter of 1940-41, and the animals were in such poor condition by late winter that they failed entirely to breed early in the year. In summer a new mast crop developed, and an exceptional production of summer young brought the fall ratio up to 44 percent juveniles.

Fig. 38. In the oak-hickory woodlots of the Rose Lake Wildlife Experiment Station, the trend in age ratios in the two years for which figures are available was much the same as at Swan Creek. From midsummer on in 1940 the proportion of young squirrels in the population evidently was reduced. The fact that a high percentage of juveniles were trapped in open situations and most adults were found in the woodlots, lends credence to the theory that competition was strong between the two age groups for the meager nut crop. In the winter of 1940-41 squirrels did not die off as at Swan Creek, but breeding in the following spring was later, and a small crop of young was produced. An exceptional amount of breeding during the summer brought the fall ratio of young up to a high level. Numerous half-grown juveniles were found in the hunting season.



The altered age ratios of 1940 recall a reference by Bennitt and Nagel (15) to a similar condition in Missouri in the fall of 1934. In that state the squirrel season opened on June 1, and hunters were easily able to distinguish young of the year by their small size during the summer. There were consistent reports from various parts of the state of a conspicuous lack of young squirrels in the kill. In this instance the dearth of juveniles appeared to be correlated with the severe drought of that year.

From these records it appears that adverse environmental conditions exert their effect first on the new generation. The food shortage in Michigan and the drought in Missouri evidently acted in somewhat the same way to reduce the proportion of young squirrels.

Sex Ratios

The relative proportion of females in a game population may be a matter of importance to the wildlife manager. Several common species, notably the pheasant and deer, are so harvested that females are preserved and the kill of males correspondingly increased. From what is now known of the habits of skunks, it would be possible, for anyone who wished, to trap at such times that mostly males would be taken (4). There is also evidence that under some conditions more male cottontails are shot (5). When squirrels are hunted in early summer in Missouri relatively fewer females are shot, due, presumably, to their preoccupation with young, and lesser activity at that season (15). In this species a deliberate differential harvesting of the sexes in fall does not seem possible. But data on sex ratios have been gathered incidental to other aspects of the Michigan studies, and they may be more useful than might appear at first sight.

Seasonal fluctuations in sex ratio among box-trapped squirrels

In 1938 and 1939 enough squirrels were trapped at Swan Creek to make possible a monthly comparison of the numbers of males and females caught. Since the population trends in the two years were much the same, it seemed feasible to combine the figures to make them larger and more significant. When this was done (fig. 39), a surprising thing was found: Females were caught

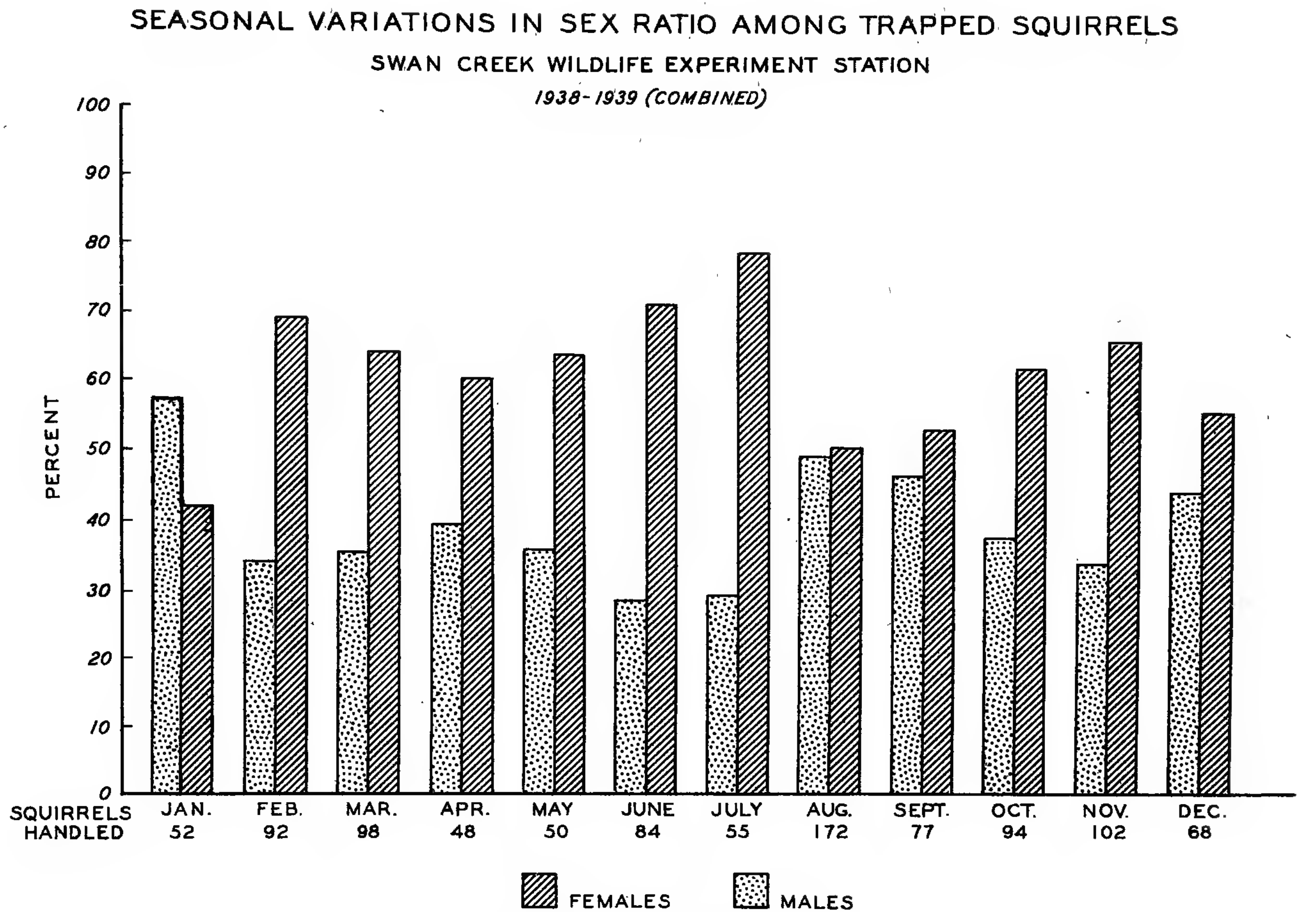


Fig. 39. In 1938 and 1939 there was a preponderance of female fox squirrels in the population at Swan Creek. A compilation of records by months shows that females were trapped more often than males in every month of the year except January. In August and September the sexes became nearly equal. This is a good example of research findings which are not yet understood, but which may be useful a few years hence.

more often than males throughout the year, except in January; and in most months enough squirrels were handled so that the trends should be trustworthy. Males and females trapped in August and September were nearly equal in number, but females were definitely predominant in the other months. Evidently we have here another of those unknowns which may be understandable and useful at some time in the future. With just these two years to consider, it might appear that the difference in sexes was due to females being more easily trapped. But subsequent information showed that there actually were more of that sex in the population.

Sex ratios from year to year

One of the most striking phenomena observed among Michigan fox squirrels is the change in sex ratios from one year to another. That the trend is real seems evident from the fact that for two years it was similar at both experiment stations. Fig. 40 gives the percent of males and females handled in the first half of the year at Swan Creek from 1939 through 1942. Similar figures are given for Rose Lake from 1940 to 1942. As an additional figure, in the early part of 1941 there were 40 male and 22 female fox squirrels removed from woodlot 17 at Michigan State College: a ratio in agreement with that found at the two stations.

Evidently there was a preponderance of females among Swan Creek fox squirrels during the period of population increase from 1938 through the spring of 1940. The proportion of males became significantly larger at the time of the food crisis and restricted breeding in the winter of 1940-41. This preponderance was maintained through 1942. At Rose Lake the trend was similar up to 1941, although the figures are smaller and a greater error can be expected. In 1942 there probably was a lower precentage of males than at Swan Creek.

The sex ratios among young squirrels handled after June at Rose Lake in the three years were:

	Number of animals			*Ratio (percent)*		
	Males		*Females*	*Males*		*Females*
1940	46	:	33	58	:	42
1941	36	:	64	36	:	64
1942	66	:	102	39	:	61

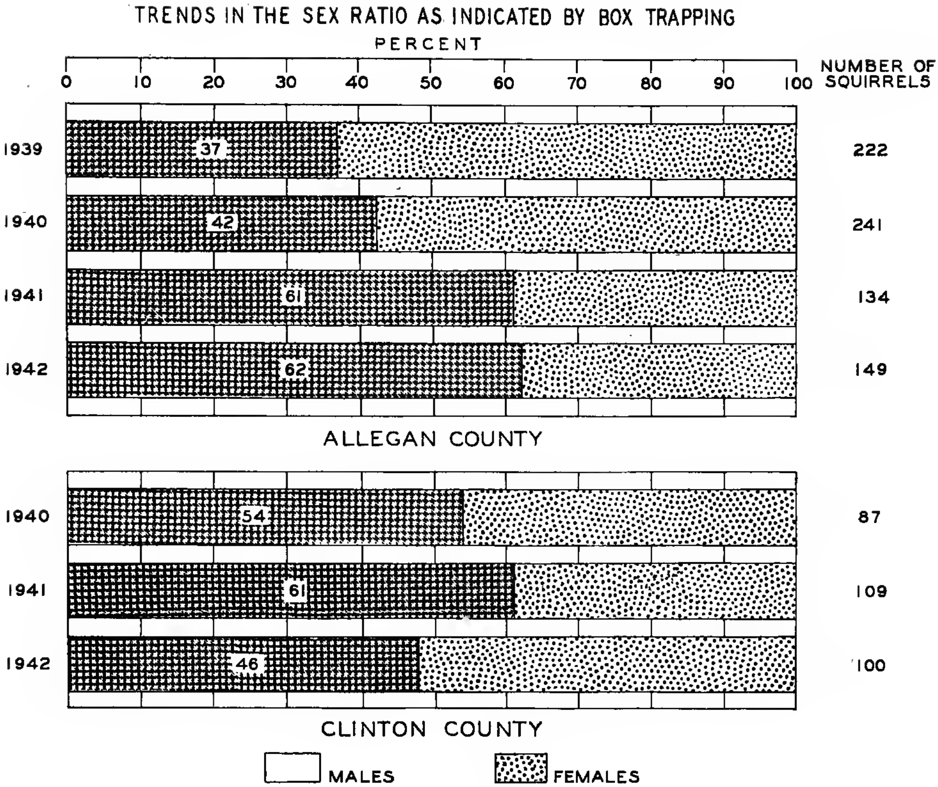


Fig. 40. In 1939 and 1940, at the Swan Creek experiment station in Allegan County, there was a marked preponderance of females in the squirrel population. This is shown by the sexes of adult animals trapped in the first half of the year. From 1940 to 1941 there evidently was a shift to male predominance. Information from Rose Lake seems to indicate more males than females in 1940 and 1941, but the number of squirrels handled was too small to be a reliable index. Perhaps it is significant that the sex ratio at Swan Creek changed coincident with a food scarcity and winter die-off.

The summer sex ratios of juveniles for 1940 and 1941 are not inconsistent with ratios among breeders in the following years. And they also agree in trend with our figures on litters. There were only 9, 4, and 10 litters found, respectively, in the three years, and the respective numbers of males and females in these were: 19:7, 5:3, and 11:18. It appears that in 1940 a preponderance of males was produced, and in 1942 a greater number of females. But, again, such small figures must be considered only as suggestive.

A similar disparity in the sexes of fox squirrels was reported by Bennitt and Nagel (15) for 1934, in Missouri. In the kill by hunters in that year of extreme drought, the proportion of males to females was more than 4 to 1. Gray squirrel kill records also showed more males taken, but the number was relatively small. The authors reasoned that, since fox squirrels were more commonly found in the uplands, the drought had affected the breeding females and their young to a greater extent than in the case of the gray squirrel, which usually inhabits the bottomlands where water is available. In Michigan kill records were not being kept at that time, and the effect of the drought years was not determined.

The sex ratio figures give further evidence that something of basic significance was happening in the Michigan fox squirrel population in 1940 and 1941. The mast shortage, local population declines, abnormal age groups, and then a reversal in the relative numbers of the sexes—all seem to be related, but just how is not clear.

In these fox squirrel studies we have been afforded a glimpse of some of the changes which have been taking place for many thousands of years among animals closely associated with man, but with little recognition on his part that human understanding of such things was incomplete. It could hardly be expected than an accurate and logical explanation of all our findings would be immediately forthcoming. But when a real understanding of them is attained, it is quite likely that such knowledge can be put to practical use.

Summary of Chapter Five

Mating activity of the fox squirrel is principally in two periods, the first in January and February, and the second in May and June.

The greatest production of young is in spring, with the most common time of birth the second week of March. Young per litter vary from 1 to 6 and average 3.

Old females ordinarily breed twice in a year and yearlings but once. The average yearly production per breeding female is approximately 4 young.

Juvenile fox squirrels are dependent upon the mother for about three months. Their eyes open in the fifth week, they begin to climb at 7 or 8 weeks, and probably most venture onto the ground first at about 10 weeks of age.

A normal fall age ratio probably is near 60 percent young and 40 percent old squirrels in a year when populations are not increasing or decreasing.

Food supplies affect breeding vitally. A scarcity may cause a failure to breed early in the year, but such a failure in 1941 was compensated by an unusually large production of young during the summer.

Significant variations in sex ratios occur from one year to the next. Increasing populations have been associated with a predominance of females.

Chapter 6

INDIVIDUAL RANGE, MOVEMENTS, AND ACTIVITY

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INDIVIDUAL RANGE, MOVEMENTS, AND ACTIVITY

MANY ASPECTS of management are influenced by the extent to which squirrels move about and the amount of land ordinarily occupied by an individual. Obviously a farmer's game problems will be one thing if he can manage his woodlot independently of the way his neighbors are handling theirs; and they will be quite another if a squirrel is inclined to use three or four woodlots instead of "staying put" in and around one.

Information on squirrel movements is not complete, but enough can be deduced from existing records for present purposes. The details can be filled in later.

Individual Range

It would be simple and convenient if we were able to say that the average home range[18] of a male or female fox squirrel was so many acres, and let it go at that. The Michigan studies have provided a large number of range records. When studied, however, such data show that the matter of individual range is far from simple, and that any "cut and dried" approach to it is likely to be more misleading than helpful.

Individual range is probably subject to seasonal modifications. It is likely that the distance an animal travels is correlated with the duration of its daily activity; and in early winter, when they are abroad least, individuals also occupy the smallest area. But in late winter, especially, food scarcity may cause them to wander far from the home nest. In March 1938, at Swan Creek, I twice tracked squirrels trapped in the study woods to nests approximately a mile away. These individuals had evidently been looking for food, and this occurred at the season when available supplies were at the yearly minimum. During the severe food shortage of 1940-41, Montgomery (76) followed squirrels on extended forays up to one and a quarter miles. Such records can, of course, be made only at the season when there is tracking snow, and movements at other times of year must be judged by trapping records.

[18]The terms "home range" and 'territory" are here used according to their interpretations by Burt (19). "Individual range" here includes the home range and the occasional longer movements that an animal may make away from and back to its accustomed haunts.

In figs. 132 through 152 (Appendix D) are shown sample ranges of squirrels as determined by repeated handling in box traps at Rose Lake and Swan Creek. Some of these were selected for the number of times the animals were caught and the length of the periods covered by their histories. Others are included to show the variation in conditions. These maps indicate that the home range of a squirrel is usually in and around the woods where its nests are located, but it is not uncommon for the animals to travel out along fencerows or to visit other nearby woodlands. An individual may shift its home range from one isolated woods to another, or it may remain in the same locality for its entire lifetime. Most young squirrels evidently do not stay in the woods where they are reared, but a few of them do.

From information now at hand it appears that an average fox squirrel uses an area at least 10 acres in extent in any one season. On a yearly basis they are likely to move about occasionally over 40 acres or more. Where woodlands are connected by strips or clumps of trees, or are in large continuous stands, squirrels seem to average larger ranges than in small isolated units. It is quite evident that the more times an animal is handled the larger its known range tends to become and that our best methods give relatively incomplete records on individuals. It is also apparent that the cover pattern in any given area largely determines where and how far a squirrel will, or must, go to satisfy its life requirements. Since the pattern of no two areas is exactly alike, it would be necessary to map many ranges in many localities to be able to say that the average home range of an adult or juvenile, male or female, fox squirrel is a given number of acres at a given season. For purposes of the management program, present knowledge on this subject probably is about all that is needed.

Although it is not certain exactly how much difference there is, nor whether or not the difference is restricted to the season of mating, there is evidence that male fox squirrels move about more than females. In the first 6 months of 1941 at Rose Lake, it was found that the 10 male squirrels with the largest ranges were taken at points averaging a maximum distance of .48 miles apart, and for the 10 females with the largest ranges this figure was .2 miles. These were selected from records of 56 males and 26 females. It was also found that 45 percent of the males handled were taken in two or more woodlots, whereas 35 percent of the females were so taken.

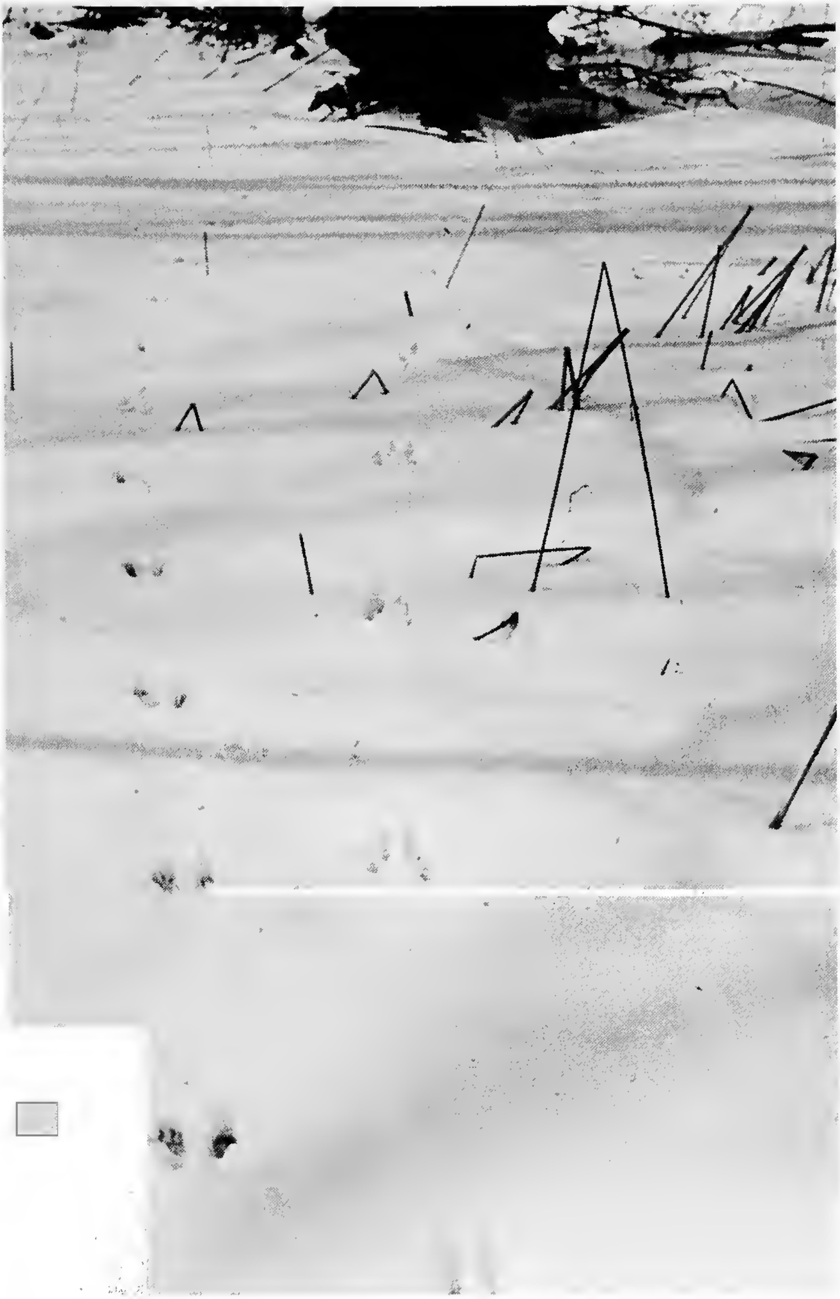


Fig. 41. If food conditions are favorable, squirrels probably do not venture far from the home den during the coldest part of the winter.

The most important conclusion to be drawn from the work on ranges is that few fox squirrels are limited for any extended period to one woodland. In Michigan, woodlots are plentiful, and any one grove is seldom more than a quarter of a mile from other units (see map of Clinton County, p. 45). Under these conditions there probably is more frequent movement from one woods to another than, for example, in the more scattered woodlots studied in the Ohio agricultural region by Baumgartner (11). A Michigan farmer who is sufficiently interested in squirrels to consider their requirements in utilizing his woodlots will also to some extent be managing his neighbor's squirrels. But this need not deter him from beneficial practices. If his own woodlands provide a more favorable habitat than adjacent stands of timber, they will be more attractive to the animals, have a higher year-around carrying capacity, and without doubt produce more game. As will be shown, there is an extensive yearly "reshuffling" of squirrel populations, and from our study of individual woodlots, it is evident that good units of range come out of this with consistently higher populations than poor ones.

Territoriality

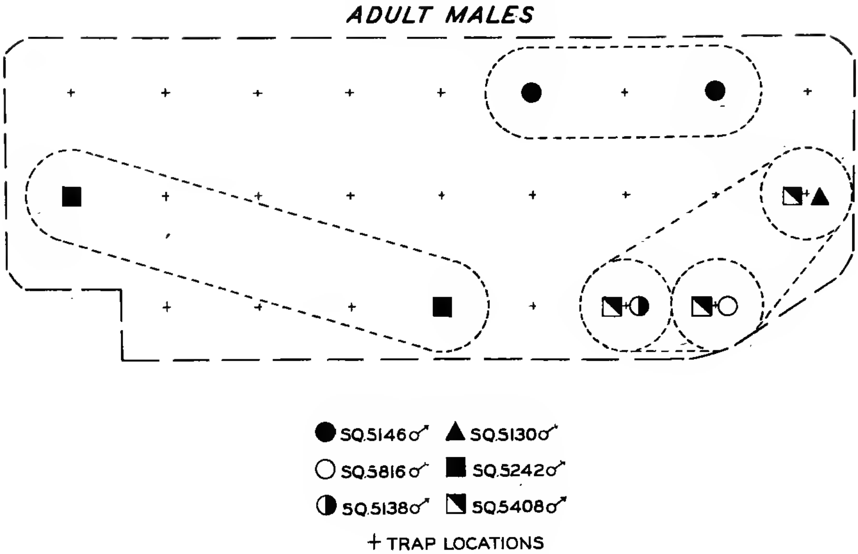
In some species of animals it has been found that in the breeding season individuals or pairs habitually establish claims to well-defined territories which they defend against encroachment by other individuals of their own species. Among some of our common songbirds it is the male who establishes a territory, attracts a mate, and then maintains it as private property. Although this behavior is best known for its occurrence among birds (79), a number of mammals, including certain mice, tree and ground squirrels, and beavers (16, 18, 46, 66), have also been observed to have territorial tendencies. It is obvious that among species which require a relatively large exclusive area for each pair or breeding group ("group" referring to the harems of pheasants, walruses, etc.) there will be a strict size limitation of the breeding population. This sociological factor among the animals themselves may in such cases determine what the carrying capacity of a given unit of range can be.

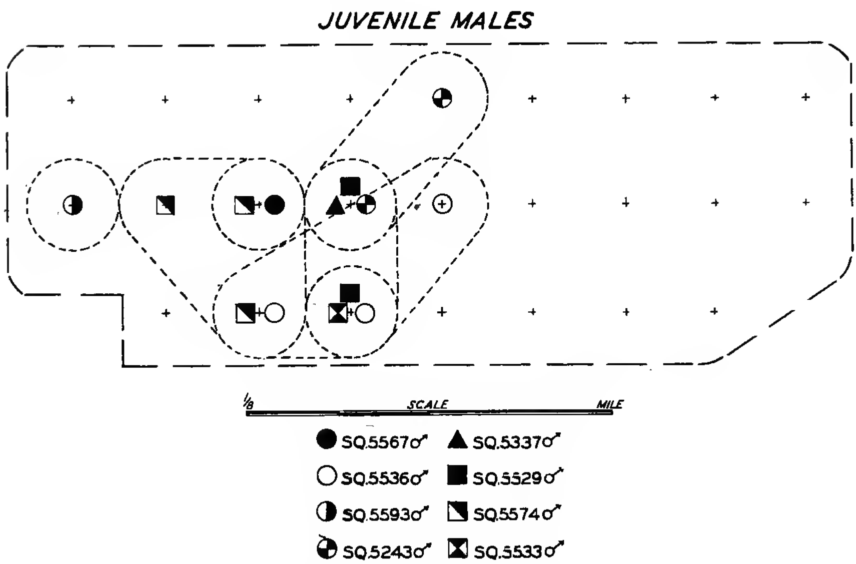
For any game animal it is necessary to know to what extent it is territorial in habit and what restrictions this may impose on

populations and hunting season productivity. In several species of ground squirrels there is evidence of exclusive ownership of restricted nesting sites or areas where food caches are located (18, 46), but the extent to which territorialism exists among most animals of this family is largely unknown.

Most evidence on the fox squirrel is circumstantial. An examination of trapline records shows that individuals of both sexes and all age groups are likely to be taken in the same traps in a given season, indicating that ranges overlap to a considerable degree. Figs. 42 and 43 give a compilation of known ranges from a woodlot at Rose Lake which illustrate this. Field observations also tend to discourage the idea that an individual fox squirrel asserts exclusive rights to any appreciable area of range. It has been evident that different squirrels may use the same nest intermittently over a period of at least a month, and one animal sometimes uses several nests or dens which may be located as much as 100 yards (or probably more in some cases) apart. It has been a common observation that a fox squirrel knows the location of all nests and dens within its own "neighborhood" and does not hesitate to use them when it is expedient. But these same observations suggest strongly that there is some sort of recognition of priority rights on the part of an animal while it is actually occupying a given nest. Following are some examples of field records that illustrate the points mentioned.

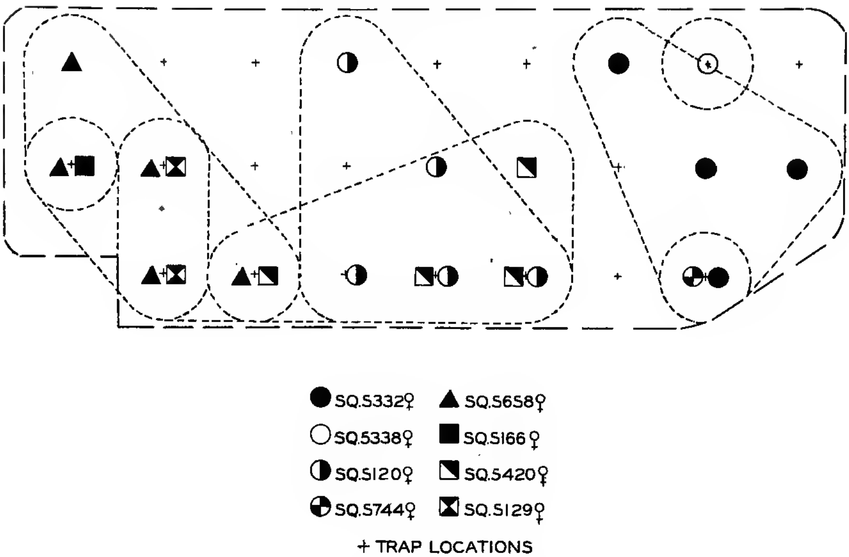
On December 14, 1938, squirrel 395 was taken in trap 29 in the squirrel woods at Allegan. When liberated, it ran southeast and treed in nest 34c. Twenty minutes later I climbed this tree and the squirrel ran out, circled through the trees to the northeast, and then came back and entered the nest. Another large nest (33a) was a short distance away, and I started to climb that tree. An unmarked squirrel ran out of nest 33a and crossed directly over to 34c which contained the marked animal. When it came to within a foot of the nest, squirrel 395 ran out and stopped about 2 feet above the structure. The unmarked squirrel appeared confused, circled, missed its footing, fell 30 feet to the ground, and then returned and perched near its original nest. Squirrel 395 reëntered nest 34c. The unmarked animal, upon being disturbed, appeared to know exactly where the other nest was and how to get there. It obviously intended to enter but beat a hasty retreat upon finding the nest occupied.



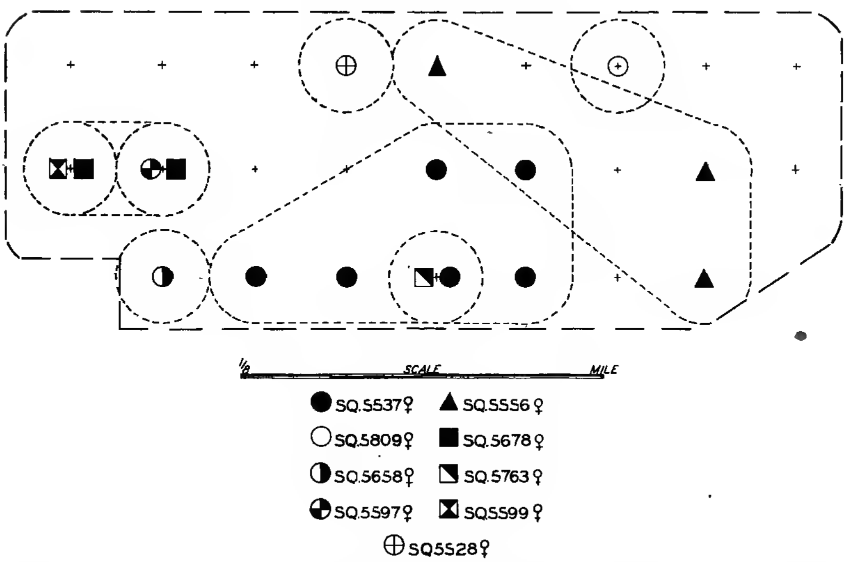


Figs. 42 and 43. Diagrams representing the known ranges of fox squirrels within an oak-hickory woodlot indicate a considerable overlap among animals of the same age and sex group. The indicated ranges are based upon box trapping in woodlot 5 at the Rose Lake Wildlife Experiment Station from April through August, 1941. These are the most complete records that have been obtained for a single woodlot in one trapping period. The ranges must be considered

ADULT FEMALES



JUVENILE FEMALES



minimum, since most are obviously limited by the method used in getting them. Data of this kind seem to indicate that individual fox squirrels do not assert a claim to any considerable land area which they defend as an exclusive "territory" against others of the same sex and/or age group. Territorialism in this species appears to be restricted to the vicinity of a nest at the time it is occupied.

A somewhat similar record was obtained by Warren W. Shapton on December 21, 1939, at Rose Lake. A male squirrel was taken from a trap, weighed, tagged, and liberated. It made a circle of about 30 yards, went 25 feet up a red oak tree and entered a hole. It immediately emerged with another squirrel behind it. The second squirrel caught the first about 10 feet down the tree and tumbled it to the ground. It lay there for an instant and then ran off through the woods.

In March 1940, another Rose Lake record was secured by D. F. Switzenberg. Three large nests were located in trees only 30 feet apart. Each of these contained a squirrel, and one was a female with a litter of young. When disturbed, one of the other squirrels ran to this nest and entered. There was a commotion and both animals emerged. The female ran to a nearby knothole and the other perched on a limb in an adjacent tree.

A sample record from Swan Creek shows the overlap in the use of nests by different animals. Two male squirrels used nest 29a in the study woods in the winter of 1937-38. On January 22 and 24, squirrel 44416 was trailed to this nest. On February 3, squirrel 44423 was liberated from a box trap and ran to it. On January 23, 30, and 31, the latter animal had been using nest 28a. Nearly a year later, on the following December 21, this same squirrel was again tracked to nest 29a and on the 24th to nest 30c. On December 8, nest 28a had been used by a juvenile female, number 378.

In connection with these records it must be kept in mind that we do not know what sexual relationships are involved. Also, a squirrel escaping from a box trap is usually frightened and may be inclined to find the first hiding place with which it is familiar. It is to be doubted that the animals habitually enter entirely strange nests, as many times they have passed up numerous nests to go as much as half a mile to a particular tree. It appears that by winter there are more than enough nests to go around, and the animals are to a great extent tolerant of one another. A large nest may be used regularly by a particular squirrel and yet serve as at least a temporary retreat for other individuals. Each squirrel seems to have several nests that it uses on occasion.

It has been pointed out in the discussion of breeding habits (p. 122) that summer juveniles sometimes remain in a group in one nest through the winter. An old female, probably the mother, is sometimes with or near these groups. In two cases Montgomery

found a pair of squirrels together in a nest just prior to the breeding season. These seem to be special family relationships.

One who tracks squirrels in the winter and observes their feeding habits probably will deduce that the burying of food is in effect a communal affair. The animals sometimes range widely and dig up food wherever it can be located. Late summer juveniles must certainly live upon the stores buried by adults, and the provisions of squirrels killed in the hunting season probably are not ignored. Cahalane (20), who made extensive observations on the food-caching activities of the fox squirrel, noted that they exhibited only a "transitory interest" in buried food, and were tolerant of one another during gathering and caching operations.

Our information on territorialism is by no means the last word on the subject. Records on individual animals are not sufficiently complete to give clean-cut results. But from evidence available thus far, it appears that territorial reactions are restricted to the vicinity of a nest at the particular time it is occupied. The habit probably has no important bearing on management.

Long-range Movements

The trips that a fox squirrel makes half a mile or a mile away from its nest and back again must be distinguished from the extended (presumably one-way) emigrations that are sometimes recorded. Most long-range movements occur during the summer and autumn. Although there is evidence that such traveling occurs in connection with the breakup of families and the annual distribution of young, records show that old animals also occasionally make extended journeys. Females have been known to bear and rear a litter and then to "move out of the country." Most of these records have been obtained at Rose Lake and Swan Creek where large numbers of animals are ear-tagged. Tags returned by hunters are the best source of such information.

Extent of movement

The longest recorded movement of a fox squirrel released at the point of capture was by a juvenile male taken in woodlot 3 at Rose Lake on July 26, 1940. This animal was handled again in the same trap on August 2, at which time it weighed 1 lb. 4 oz. In the hunt-

TABLE 8

Records on Long-range Movements of Fox Squirrels from Swan Creek Wildlife Experiment Station

First taken at Swan Creek	*Number*	*Sex*	*Last handled at Swan Creek*	*Age*	*Recovery date*[19]	*Approximate time elapsed*	*Approximate distance traveled*
12/14/38	555	♀	12/14/38	Ju.	Nov. 1939	10½ months	10 mi.
8/29/38	197	♀	9/ 1/38	Ju.	Oct. 1940	13½ months	21½ mi.
4/21/39	684	♂	4/21/39	Ad.	10/15/39	6 months	19½ mi.
8/29/39	1344	♂	8/29/39	Ju.	Oct. 1939	1½ months	3 mi.
8/31/39	1299	♀	8/31/39	Ad.	10/20/39	1½ months	13 mi.
4/27/40	6053	♀	4/27/40	Ju.	10/20/40	5½ months	10 mi.
5/14/40	6084	♀	5/14/40	Ad.	10/20/40	5 months	9 mi.
6/ 5/40	6532	♀	6/ 5/40	Ju.	10/31/41	17 months	10½ mi.
6/29/40	6556	♀	6/29/40	Ju.	Oct. 1940	3½ months	13½ mi.
7/20/40	6603	♀	7/20/40	Ju.	10/22/41	15 months	6 mi.
7/26/40	6660	♀	7/26/40	Ad.	Oct. 1940	3 months	6½ mi.
7/26/40	6661	♀	8/ 1/40	Ju.	10/20/40	2½ months	11 mi.
8/ 3/40	6681	♀	8/ 3/40	Ju.	Oct. 1940	2½ months	11 mi.
8/ 8/40	6802	♀	8/ 8/40	Ju.	Sept. 1940	1 month	8½ mi.
8/28/41	7356	♀	8/28/41	Ad.	10/15/41	1½ months	3 mi.
9/12/41	7236	♀	9/12/41	Ad.	10/16/41	1 month	3 mi.

[19]Nearly all of these returns were from hunters who shot tagged squirrels and furnished the information.

TABLE 9

Records on Long-range Movements of Fox Squirrels from Rose Lake Wildlife Experiment Station

First taken at Rose Lake	*Number*	*Sex*	*Last handled at Rose Lake*	*Age*	*Recovery date*[20]	*Approximate time elapsed*	*Approximate distance traveled*
8/11/39	5008	♂	8/11/39	Ju.	Oct. 1939	2 months	5½ mi.
12/22/39	5075	♀	7/16/40	Ad.	Oct. 1940	3 months	10 mi.
2/16/40	5113	♂	8/ 9/40	Ad.	Nov. 1940	3 months	16 mi.
7/15/40	5567	♂	7/29/40	Ad.	10/18/41	14½ months	9 mi.
7/26/40	5709	♂	8/ 2/40	Ju.	10/24/40	3 months	40 mi.
5/ 7/41	9899	♂	5/ 7/41	Ad.	10/20/42	17½ months	2 mi.
7/14/41	10266	♀	7/27/41	Ad.	11/ 2/41	3 months	3 mi.
9/23/41	14879	♀	9/23/41	Ju.	10/15/41	3 weeks	7 mi.

[20]All records from hunters who returned the tags of shot squirrels.

ing season, about 11 weeks later, it was shot in Wheeler Township, Gratiot County, approximately 40 miles from where it was born. The place of birth was known because this squirrel was one of a brood of five males found in a leaf nest in woodlot 3 on April 2. The nestlings were toe-clipped for future identification.

In tables 8 and 9 are given some records from the two experiment stations. It is obvious that most of these movements took place in late summer. Further evidence of this seasonal tendency to travel will be discussed in the section following.

The cases cited are all squirrels caught in the wild and liberated immediately at the trap. In experimental work several dozen squirrels were caught in woodlot 17 at Michigan State College and liberated at a point east of the Rose Lake station about 15 miles from the place of capture. Returns from hunters have shown that these animals, released in unfamiliar terrain, had a marked tendency to travel. One of them was reported at Clark's Lake southeast of Jackson, approximately 46 miles from the point of liberation. It took the animal a maximum of 2 months and 23 days to cover this distance. Some of these "stocked" squirrels moved only a mile or two, but others moved much farther.

The Annual "Shuffle"

Since the early stages of the Michigan squirrel work, a marked annual increase has been observed in the activity and movements of these animals at the time of mast harvest in late summer and fall. It was also evident from records on individuals that animals were inclined to shift their ranges at this season. Several persons having "pet" squirrels in their dooryards reported that the young animals mysteriously disappeared in late August or thereabouts. One of the best records of this kind is from William B. Mershon in Saginaw.

Several years ago a spring litter of three fox squirrels with dark heads and silver tails (p. 344) were reared in Mr. Mershon's yard. During the summer, after they were well grown, they all disappeared simultaneously. Curious as to what became of them, Mr. Mershon advertised in the newspaper and received reports on all three within a week. One was seen about 7 blocks to the northwest. Another was reported 1½ miles east, and the last was killed by a

Daily Activity

A squirrel hunter who wishes to know what time of day to arrive at his favorite stump to watch for his favorite game had best consult the work of Ellis A. Hicks in Iowa (56). For a year and a half this investigator made periodic 30-minute "spot counts" of fox squirrels seen in different portions of a 250-acre tract of woodland. An analysis of his findings has given the best information yet obtained on factors governing daily activity.

Hicks found that precipitation of any kind, rain, sleet, or snow, tends to decrease squirrel activity. The same can be said for fog or mist. High winds or low temperatures also reduce movement among the animals. The heat of midsummer evidently was in part responsible for decreased activity during July and August. And on cloudy days squirrels were abroad less than on sunny ones. As to time of day, this species showed a peak of activity at 8 to 10 a.m., with a smaller peak coming at 1 to 2 p.m. Seasonally, Iowa fox squirrels are most active in fall and least active in winter.

These observations agree very well with our general field records in Michigan, although having been taken quantitatively and systematically, they are more significant than anything obtained here. Judging the effect of weather on squirrel activity is complicated by the necessity for analyzing several factors at once. A given observation is affected by temperature, ground conditions, time of day, cloudiness, and many other things. To say just what caused an animal to react in a certain way requires a large number of records, so that each individual variable can be evaluated under a great variety of combinations of other factors.

One of the most significant points concerning activity is the tendency of this species to "hole up" during cold winter weather. There are sometimes periods of a week when hardly a squirrel will be seen. For example, in the Allegan County oak woodlands there was deep snow with a crust and a period of exceptionally cold, stormy weather from December 13 to 20 in 1937. During this period no squirrels were caught in box traps and none was seen in the course of field work. On the 20th the sun came out, the temperature rose, and the species became active. For the next three days they were frequently observed, and individuals were taken daily in traps. Figures on squirrels handled in the squirrel woods at Swan Creek further illustrate the restricted movement of early winter:

	Early winter	*Late winter and spring*	*Late summer and fall*
1938	6	12	19
1939	7	12	24
1940	8	16	22

It would naturally be expected that fall would show a higher number of individuals taken because the population is greater at that time, and due to extensive movements non-resident animals tend to be caught. But there is no reason to doubt that the low figure for early winter indicates reduced activity. How activity enters into winter survival and correlates with habitat and food supplies is discussed in chapter 7 (p. 174).

Summary of Chapter Six

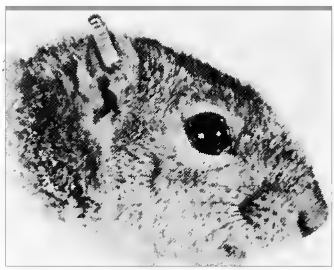
Returns from box-trapping show that a fox squirrel usually occupies an area at least 10 acres in extent in any one season, but during an entire year an individual may move about occasionally over 40 acres or more.

Since the animals are not confined to one woodland, a farmer who carries out improvements for the species will to some extent be managing his neighbor's squirrels.

The ranges of fox squirrels overlap, and the animals are somewhat communal in their use of nests and probably also in their use of winter food stores. Territorialism appears to be restricted to the immediate vicinity of an occupied nest.

It is not uncommon in summer and fall for a squirrel to move from a few to 40 miles. This appears to be associated with a general redistribution of populations in which young of the year scatter and numbers are brought into balance according to the carrying capacity of various units of range. In what was probably a representative year the annual "shuffle" began in late August, reached its height a month later and tapered off to early December.

Early winter is the season of least activity, and daily movements are reduced by unfavorable weather extremes at all seasons.



Chapter 7

WHAT HE EATS

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WHAT HE EATS

IT HAS BEEN said of human beings that we are just three meals from barbarism, and that our armies travel on their stomachs. A constant necessity for food is one of many characteristics which we share with other living things, and this has made it easy to realize the importance of adequate food supplies to wildlife. Such simple relationships are evident and easily understood, with the result that food patches and winter feeding have become widely advocated as management techniques. Most wildlife studies have shown that habitats favorable enough to support any considerable numbers of a given animal are sufficently supplied with food for all ordinary requirements, and that artificial feeding is largely an emergency measure. In order that the nature of such emergencies will be understood and anticipated for each species, the wildlife technician must have a good conception of the seasonal food requirements of creatures with which he deals.

Most wild animals have become adapted to feeding upon particular things, and the fox squirrel is not exceptional in this respect. In the public mind, it is as closely associated with nuts as the whale is with Jonah. What is not ordinarily appreciated is the wide variety of things even highly specialized animals eat. Aesop was not at all far fetched in attributing to the fox a liking for grapes. The skunk is more likely to be found gathering chilled grasshoppers of an early morning, or nosing in a thicket for dogwood fruits, than plotting the demise of the farmer's leghorns. And similarly, such habitual mast feeders as the many kinds of tree and ground squirrels have a well-developed taste for eggs, insects, and "red meat." There are certain staples which to the fox squirrel spell existence, but his life, too, is spiced with a wide variety of seasonal delicacies; and in seasons of want, there are *ersatz* items which will temporarily fuel his hardy engine until the advent of better times. What is known of the feeding habits of this species has been learned largely through observations in the field by various interested people during the past century (2, 9, 20, 64, 75, 76, 78, 86, 95, 99, 108).

Seasonal Feeding Habits

Practically every kind of vegetable food the land produces, from beneath the soil to the treetops, is available to fox squirrels. Their methods of obtaining nourishment vary with the season, and a consideration of such habits is a good prelude to discussion of the important staples which need to be given greatest emphasis in a management program.

Spring

In March, April, May, and early June most female fox squirrels are caring for their hungry litters. Upon a mother's ability to find plenty of nourishing food depends the thrift of her offspring. The melting of winter snows has laid bare the ground for easy foraging, and many buried nuts and acorns of the preceding fall are used at this season. Buds are also much utilized, particularly those of maples, elms, basswood, willow, and oaks. The immature and adults of many kinds of beetles and other insects are found in the moist duff of the forest floor, around decaying logs, and on bark and twigs of trees. Seton states that tubers, bulbs, and roots are dug up and eaten. The flowers of maple and elm, catkins of willow, and fresh green sprouts and leaves of various early spring plants add moisture and doubtless vitamins, even if their nutritive value is low. Bones are often carried to an old nest or other perch where they are gnawed by fox squirrels in common with the flying squirrel and woodmouse. This source of extra calcium is probably of particular importance to females with young. In late May and early June the winged samaras of soft maples (red and silver) ripen,

Fig. 45. Twigs of slippery elm clipped by a fox squirrel. Buds are a common winter food.

W. C. Gower

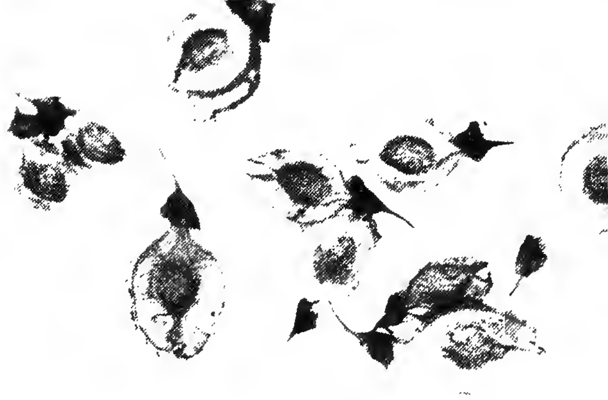


Fig. 46. Samaras of soft maples (left) and the seeds of elms furnish a plentiful supply of spring food in some areas.

and in some localities they produce food in abundance. Such a plentiful supply probably eases the difficulties of self-dependence for spring juveniles beginning to forage for themselves at that time. Fruits of elm are important in some places, and seeds of poplar are utilized at this season. Corn which has been left in the field until spring is used as long as it is available. Ears may be carried half a mile or more to some favorite stump or eating perch in the woods where the embryo is gnawed from each kernel and the remainder dropped for the benefit of pheasants, quail, or in some areas, ruffed grouse. Occasionally, at such places, eggshells bear witness that these birds have paid for any services rendered by the fox squirrel. At the Kellogg Farm, where turkeys and ducks were nesting in the edge of a marsh and the surrounding woods, fox squirrels not infrequently visited clutches and managed to make off with portions of even large turkey eggs. Robin eggs are known to have been taken, and in one case evidence was good that a bluejay, an omelette connoisseur in its own right, contributed three eggs to the fox squirrel cause.

Spring staples are mast of the previous fall, waste or field-standing corn, and seeds of spring-fruiting trees. The large or small supply of these makes the season one of plenty or one of want. Allegan studies showed that where dependence was practically complete on one staple, in this case acorns, and that supply failed, the new squirrel crop also failed.

Summer

In June the season of fleshy fruits is opened with the ripening of serviceberries and wild strawberries. In most areas there is a certain amount of this kind of food—raspberries, blackberries, blueberries, elderberries, dogwood, wild grape, chokeberries, wild cherries, greenbrier, plums, haws, and others—available all summer. Especially in dry seasons, or where other foods are not plentiful, green apples and pears by the peck are opened and their seeds eaten. The pits of such drupes as wild plum, cherry, and dogwood are also acceptable fare. In mid-July hickory nuts are in the "stiff dough" stage, and that is ripe enough for the squirrels. If the supply is small, little of it will remain by fall. In July and August the hard maples (sugar and black) bear an abundant crop that is not neglected. At this season also, basswood, box elder, and black

Fig. 47. Shells left at the base of a tree testify to the fox squirrel's liking for eggs.

Fig. 48. Summer foods of the fox squirrel include such fleshy fruits as wild grape, bittersweet, Virginia creeper, wild cherry, plums, and haws. These are plentiful in brushy fencerows.

ash have ripening fruits which may help to round out the menu. In some years, of course, certain species fail to bear; in fact, in the northern portion of this state, poor crops are probably of more frequent occurrence than good ones.

In farmland, green corn is esteemed as a late-summer food. It is not unusual, where cornfields border woodlands, to find numerous ears torn open and either sampled or completely stripped of their milky kernels (fig. 50). Some ears are gnawed from the stalk and carried into the woods. Sometimes the farmer pays several bushels of summer roasting ears for the squirrel pot pies of autumn.

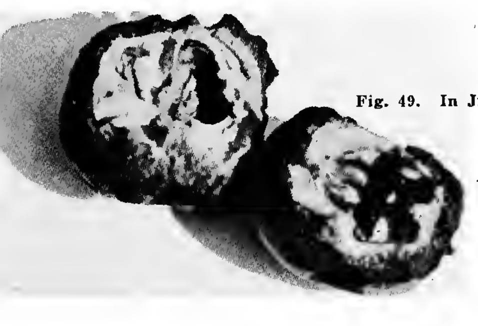


Fig. 49. In July squirrels begin to use the new hickory-nut crop.

Fig. 50. High on the list of favorite late-summer foods is green ear corn.

R. D. Montgomery

Green foods predominate in the squirrel's summer diet; but even at this season it is not unusual to find evidence that unsprouted acorns of the year before have been dug up and eaten. Animal foods are plentiful, and the larvae, pupae, and occasional adults of beetles, moths, and other insects are frequently eaten. Grains such as wheat, oats, and buckwheat, and wild seeds are taken at least occasionally. In spite of the large variety of foods which can be available in summer, an inventory in any one area may reveal that two or three items are of greatest importance, and ripening nuts are usually foremost in this respect. When the mast crop fails, there is circumstantial evidence that cornfield and orchard are likely to be more frequently visited, to the discontent of their owners.

Fall

To the mast-eating rodent "good times" means an autumn when there are more nuts and acorns than any reasonable number of his kind could possibly utilize. Such a harvest occurs periodically, and at such times, squirrels get as fat as corn-fed hens. In Michigan the small-fruited[21] and shagbark hickories; white, swamp-white, bur, black, and jack oaks; black and white (butternut) walnuts; and beech are the important mast producing trees. The hazelnut is our only important mast-bearing shrub. The habits of squirrels in storing this kind of food for the winter are as proverbial as the similar industry of the bee and the ant.

Unlike red squirrels, the larger species does not hoard its winter supplies in large caches. Rather, each nut or acorn is tamped into a small hole dug an inch or less into the ground. It is then covered with earth, and the leaves and duff scratched over it again. All fall this activity goes on through most of the daylight hours, and the total quantity of food thus stored must be enormous. It has been estimated that in many cases 90 to 100 percent of the total crop of acorns is taken by squirrels and other rodents (67).

[21]Locally called, or mistaken for, pignut, the range of which in Michigan has not been determined.

Fig. 51. "Good times" to the fox squirrel mean a fall in which there is more mast than his kind can possibly utilize.

The importance of mice as food competitors of the fox squirrel probably has not been sufficiently recognized. Woodmice are usually present in large numbers in habitats frequented by fox squirrels, and these small animals store large quantities of the same nuts and seeds used as food by the large species. At Rose Lake it appeared that mice did away with by far the greater part of the hazelnut crop within a week after the fruit dropped.

From the nature of the crop, it is well that squirrels put away much while they can; for bountiful seasons are sometimes followed by years of scarcity, and some nuts beneath the leaves will keep fresh and edible for more than two years. Doubtless many an acorn is never dug up and remains to sprout and fulfill its destiny as a great oak. However, as shown by the experiments of Cahalane (20), under some conditions the animals may by spring find as many as 99 percent of the nuts buried in the previous fall.

It seems likely that much of the winter provender is not used by the animal that buried it. Squirrels may range a mile or more from their nests in winter and dig up mast wherever it can be found. Summer juveniles which mature in autumn would have little time to bury winter supplies, and this age-group must be largely dependent upon the stores of other animals.

In this connection it appears that our late hunting season may well have another value. All squirrels are busily burying nuts in September and October. October and November hunting removes half-a-million-plus animals from the population and leaves their stored food safely underground to nourish those which are left through winter and spring. The hard winter of 1940 showed that little food means few young; and conversely, more food very likely means more young. It seems logical that this large fall kill is

Fig. 52. The woodmouse, or white-footed mouse, lives in the same habitats as the fox squirrel and is one of its most important food competitors.

J. P. Linduska

beneficial to the production of a new crop, since it removes early in the season a part of the yearly surplus which would otherwise be eliminated in the competition of the cold season.

Terrill (95) has described the fox squirrel's habit of grasping twigs and hanging head downward while it clips fruits or nuts from the tree. Many of these it eats on a favorite perch near the trunk. Others may be allowed to drop to the ground and are picked up later. It has been particularly noticeable that squirrels habitually clip bud-bearing twigs and allow them to fall. The snow under a slippery elm or other favorite feeding tree may be littered with twigs on many of which the buds have not been touched. In cutting twigs for a nest a squirrel usually uses them one by one, but sometimes it clips a quantity, allowing them to fall to the ground to be carried off later. Unaccountably, the animal may leave such items where they fall without using them.

The author cited above (95) observed an interesting habit of fox squirrels in feeding upon walnuts. The animals picked green nuts, carried them to the ground, and bit holes in the hulls. These were allowed to lie on the ground for several days during which flies laid their eggs in the injured hull and the work of the larvae caused it to become brown and pulpy. The squirrels then were able to hull the nut with a couple of bites, and the clean nut was either buried or eaten. This was almost invariably the treatment given this type of food.

Ordinarily, mast is of such importance in the fall that other foods appear of little consequence by contrast. In most areas there is seldom extreme scarcity at this season, and it is then that squirrels reach their maximum body weight. The fall abundance is used in two ways: it is cached in the ground, or stored away on the animal's body in a thick layer of fat. When oaks and hickories fail to bear, and squirrels are thin, a hard winter may well ensue.

Winter

A much-discussed mystery of squirrel behavior has been the relocation in winter of nuts buried in autumn. There is little question that the animal does this by a keen and specialized sense of smell. They will sometimes hop, sniffing, over the surface and then dig through a foot of snow straight to the acorn under the leaves. They find ears dropped by the corn picker in the same way. They seldom dig without having something to show for it. In winters when

snow is deep for a long period, fox squirrels may make extensive tunnels at ground level beneath a favorite hickory tree (fig. 53). Evidently this is easier than digging for each individual nut.

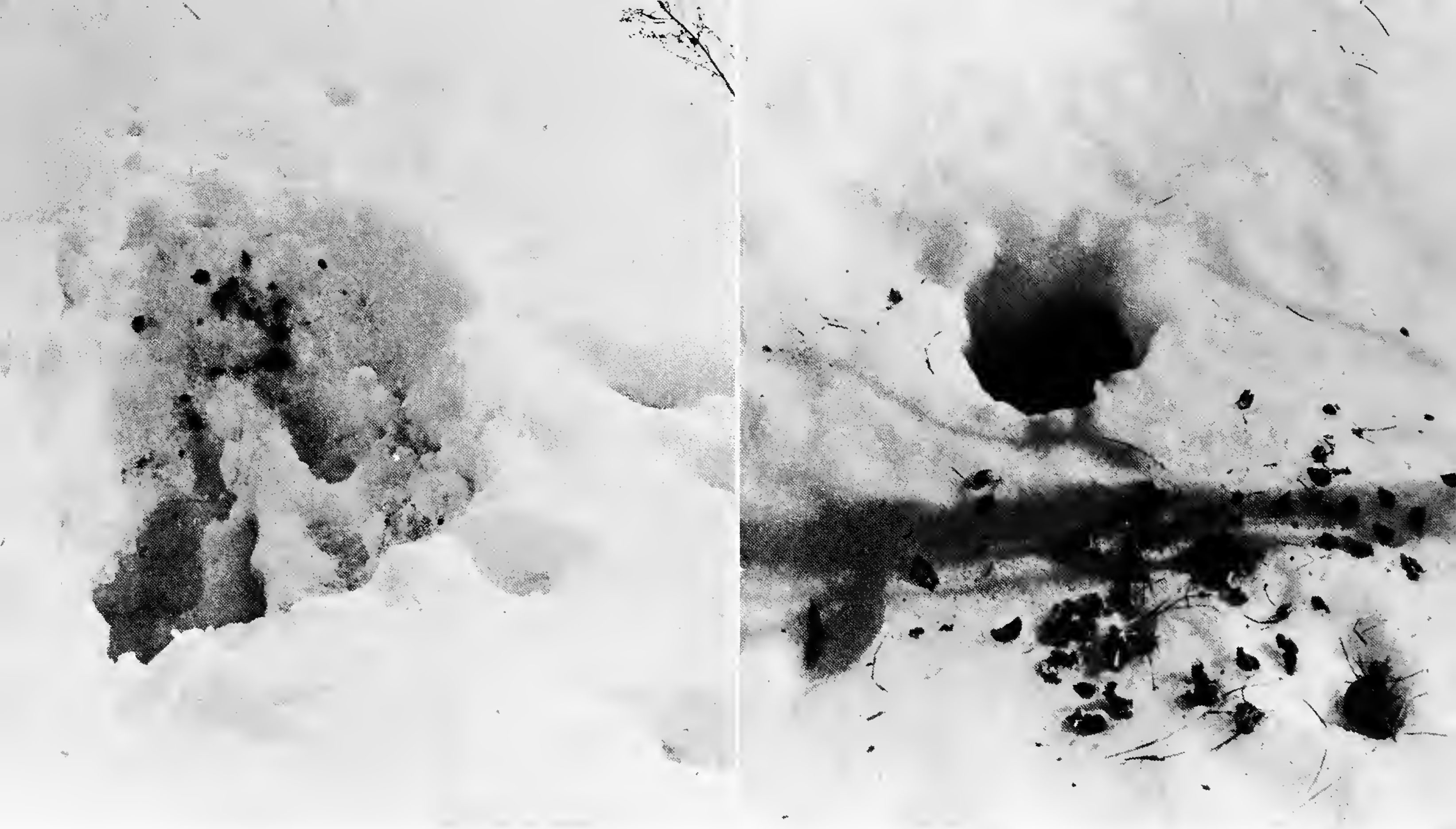
Cahalane (20) carried out some illuminating experiments on the ability of fox squirrels to find buried nuts. In the fall he buried a series of hickorynuts at depths corresponding to the depths of squirrel-made caches. In the following spring it was found that of 168 nuts partly buried in the soil and covered with ground litter, only 1.2 per cent remained. Of 96 nuts buried ½ to 1 inch in the ground, 43.8 per cent were still there in the spring. It was evident that memory could not be the guiding factor in the location of food caches, although the author concluded that it probably did serve to localize the area of search, since the animals found a significantly greater percentage of the nuts they had buried themselves.

Cahalane performed a series of experiments with laboratory animals, which showed clearly that a certain amount of moisture must be present for the odor of a nut buried in soil to be perceptible to a fox squirrel. The animal could find very few of the nuts buried in dry dust. Dice (29) also found that a fox squirrel accustomed to coming to his porch for walnuts was unable to find them if they were covered in a box of dry sand.

The ability of fox squirrels to find buried nuts imposes a restriction on the method of planting forest trees where these animals are common. In the fall of 1936 the forestry class of Michigan State College planted a quantity of walnuts near the woods on the W. K. Kellogg reforestation tract near Battle Creek. During the winter, it appeared that squirrels found and dug up every nut, since none survived.

Of course, their keeping qualites make nuts the most important winter food of fox squirrels, and oaks doubtless furnish the greatest supply in most years in southern Michigan. In Missouri Terrill (95) observed that although oaks constituted an estimated 70 percent of their food, the animals preferred such food as hickorynuts, walnuts, hazelnuts, and corn. In one area he found that the supply of walnuts was completely exhausted before fox squirrels began feeding upon white oak acorns, although the latter had been available for nearly a month. White oak was found to be preferred over black oak, but this author placed the oaks in general twelfth on the list of preferred foods in Missouri.

In farmland, cornfields are dependable sources of winter food, and corn can be classed with mast as an important staple. Squir-



J. P. Linduska

Fig. 53. Fox squirrels can locate their food, by scent, through a foot of snow (left). When snow is deep the animals sometimes make tunnels in which they hunt for food at ground surface (right).

rels may spend the winter in a few trees or small corner of woodland near shocked corn. At the Rose Lake station, the ground was strewn with cobs in a 2-acre woods beside a field of standing corn in the winter of 1940. Corn was the only food supply, and it was taken in by the farmer during April. In May not a squirrel could be found in this woods. This is an example of how these animals move around with the seasons to avail themselves of favorable combinations of food and cover.

It sometimes happens that trees in open fencerows are little visited by squirrels in the fall, so that the bulk of the nuts lie on the ground to be covered with snow. During the winter these trees may be sought out and used as feeding sites (fig. 54). Squirrels do not hesitate to cross several hundred yards of open field to reach such a supply. Well grown fencerows make such trips less hazardous and themselves contribute to the winter bill of fare. At the Kellogg Farm, squirrels and pheasants packed the snow under a fence grown up to seed-laden vines of the climbing false buckwheat *(Polygonum scandens)*.

Fig. 54. Isolated trees sometimes are little visited until late winter when the woodlots have been well picked over. Then the abundant nut crops produced attract squirrels into open fields and fencerows.

Fig. 55. Bark chipped by fox squirrels from a hard maple in late winter. It is probably the sap that the animals like.

Other supplementary fall foods of fox squirrels are the fruits and seeds of such trees as locust, hop-hornbeam, osage orange, basswood, pine, ash, pawpaw, hackberry, and those of many shrubs and vines.

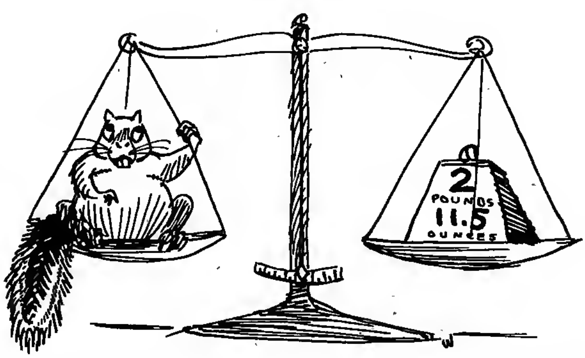
Following a season of little mast, wintering fox squirrels are reduced to a variety of less nutritive foods. Foremost among these are buds, some of which are eaten every winter. Persistent fruits like the bittersweet, hackberry, haws, rose hips, and wild grape also help to fill in. Nearly every winter some bark is eaten, and in some years damage to trees is extensive. The sugar maple is the favorite in this respect (p. 323), but elm, red maple, and beech are also taken, and Seton mentions the sweet birch and basswood.

Montgomery tracked two apparently starving squirrels on forays for food in 1941. On a trip of nearly a mile, one of these found several two-year-old acorns and ate red maple buds, portions of two fungi on white oak, and bark from a black oak windfall. In riverbottom habitats the persistent samaras of ash and box elder help tide squirrels through "lean" seasons.

It is a common conception that winter is the seasonal "bottleneck" for small game, and that the main job of management is to bring an adequate breeding stock through this period. This probably is not true for the pheasant and the rabbit, Michigan studies having shown that it is the survival or non-survival of young which chiefly determines a large or small hunting-season crop (2, 53). For fox squirrels, however, winter actually is the critical period. That it is the breeding season is also significant. Successful wintering and successful breeding depend upon adequate fall food supplies. To see that these supplies do not fail is a large part of the squirrel management job.

Food Supplies and Body Condition

Anyone who shoots half a dozen squirrels in a given woods can get a fairly good idea of conditions affecting the species in that locality by examining the animals themselves. A thrifty specimen has a glossy, heavy coat, a quarter to half an inch of fat beneath the skin of the belly, and fat around the kidneys in the body cavity. Such a squirrel signifies healthy living conditions. On the other hand, animals which are not doing well have no fat either beneath the skin or among the viscera. From one habitat to another, the weights of squirrels vary consistently, as will be shown.



THE HEAVIEST SQUIRREL IN 4000.

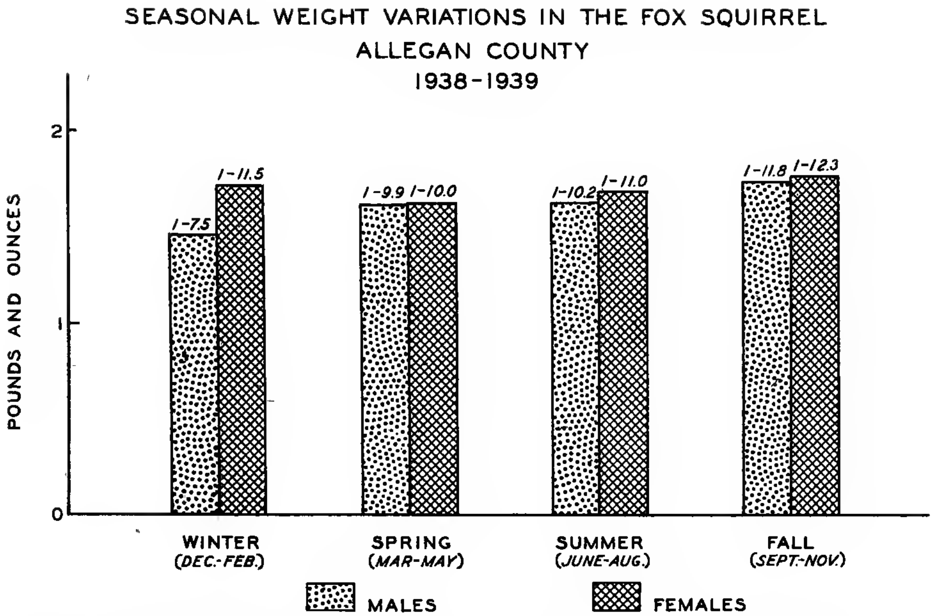


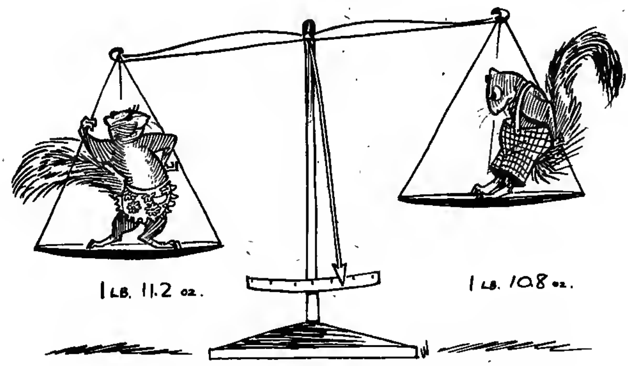
Fig. 56. Seasonal weight fluctuations of adult fox squirrels in Allegan County during 1938 and 1939. This tabulation is based upon 409 animals. The average year-round weight of males was 1 pound 10.8 ounces; the average female, 1 pound, 11.2 ounces. The average adult squirrel was 1 pound 11 ounces.

Seasonal changes in weight

In 1938 and 1939 at Swan Creek weights were obtained on 409 adult fox squirrels. The averages for each 3-month period of the year are given in fig. 56. For compiling these figures, where an individual squirrel was handled more than once in a given quarter, the weight taken nearest the middle of that period was used. As to age, spring juveniles were considered adult after November and summer juveniles after February. These samples show that throughout the year females weigh slightly more than males, and that in fall fox squirrels reach their yearly maximum.

Weight fluctuations are definitely correlated with food supplies. In autumn, with the annual peak in food, the average adult fox squirrel weighed 1 pound 12 ounces. This declined through the winter to 1 pound 10 ounces in late winter, and the animals then gained weight through summer and fall again. In its details, this

sample must be considered as applying to the Allegan area only, in this particular period of favorable conditions; but there is no reason to doubt that it illustrates the general trend in all of our squirrel range.



FEMALES WEIGH SLIGHTLY MORE THAN MALES.

Belly fat and winter activity

That weights of squirrels can vary markedly within a distance of less than a mile is shown by animals taken in a stretch of Swan Creek bottom in the fall of 1937. In scrub-oak uplands few squirrels were fat. The average upland squirrel in that year weighed about 1 pound 10 ounces. Four squirrels taken in the stream bottom during the hunting season were conspicuously different. Of the two largest, only one was weighed, and it scaled 2 pounds 10 ounces. The hunter who got these brought in another weighing 2 pounds 6 ounces, and a very large squirrel was seen but not shot. A fourth squirrel collected in this area in late November weighed 2 pounds 4 ounces. All of these animals were "rolling in fat." That these weights were exceptional is seen in the fact that 2 pounds 2 ounces was the maximum weight of any upland squirrel handled in three years, and it was an unusual animal which exceeded 2 pounds. Certainly in Swan Creek bottom there was some food or foods which enabled squirrels to "lay on the bacon," but the limited amount of field work possible at that time did not reveal what it was. In the Michigan studies, more than 4,000 weights have been obtained, and the heaviest specimen weighed 2 pounds 11.5 ounces. This is probably near the maximum for the species in this state.

An inadequate food supply leaves wintering squirrels undernourished and necessitates a maximum amount of exposure to weather and enemies in foraging for daily rations.

Field work during the winter of 1937-38 in the area where the fat animals were found showed that squirrels were much less active than in the nearby uplands. Tracks were plentiful in the scrub oaks at times when none could be found in the creek bottom. There were plenty of good natural tree dens in this locality, and in December tracks showed that they were being used; but during the storms, cold weather, and deep snow that followed, hardly a track could be seen. In March several animals in good condition, but not exceptionally fat, were taken in a few traps operated for a week along the creek bank.

It seems evident that there was a correlation between fall conditions, reflecting amounts of food available, and winter activity. Thin squirrels had to forage during cold weather, risking natural enemies and the even greater hazards of exposure. There were two records of upland animals which were inactive in leaf nests for a minimum of three days each, but the fat individuals of the lowlands may have remained holed-up for a week or two when it was safest to do so.

Are we not here getting our sights on the "formula" for which the wildlife technician must aim? Food abundance; mast stores in the ground to be utilized in good weather; belly fat to be used in the safety of a tree den in bad times—it begins to show where our squirrel management efforts must be directed.

Fat squirrels can remain inactive in bad weather.

Mast Production

The Michigan trees which make this region habitable for the fox squirrel are, in the probable order of importance, the oaks, hickories, beech, maples and elms, and walnuts. Maples and elms come before walnuts in this listing because the latter are not so plentiful as they once were. Soft maples and elms, which bear their seed in spring, are important to the new generation of young animals in May and June. The hard maples are doubtless a boon to second-litter young in July and August, and they probably help to fatten all squirrels in the period when the more enduring fruits of oaks and hickories are being buried in the ground. It is evident that the greater the variety of these trees which occurs in a given area, the more dependable the squirrel's food supply will be.

The nut-bearing trees flower in April and May. The pistillate, or female, flowers are borne on short stems, usually in clusters, and take one or two years to develop into mature fruit. The staminate, or male, flowers are borne on short or pendulous catkins on the same tree. These trees are wind-pollinated, and here a point of interest enters. It is possible that occasionally a sufficiently long wet period occurs in spring to curtail the fertilization of flowers. However, frosts appear to be the most important factor in reducing mast yields. Late frosts do like damage to the squirrel's acorns and the farmer's peaches, and this accounts for the greater frequency of mast failures the farther one goes north in the lower peninsula. Factors governing mast production are only now beginning to be studied. In a few years we shall know much more about such things, but some principles have already come to light which will be useful in management.

Dense stands and open-grown trees

At the Rose Lake Wildlife Experiment Station, mast production was first sampled quantitively in the fall of 1940. The oaks yielded nothing. Hickories in woodlots also bore nothing except for a very

Fig. 57. Trees grown in the open develop large crowns and produce more consistent and more abundant crops of mast than those in dense stands.

few nuts on edge-growing trees. Hickory trees in pastures and fencerows produced small crops of nuts. Medium-sized small-fruited hickories averaged about 8 quarts of shelled nuts—considerably less than a good crop, but better than nothing. All of the walnut trees on the area are in the open, and a fair crop was realized, large trees averaging about one and three-quarters bushels of nuts.

It is a well known fact that open-grown trees of all kinds bear larger and more consistent crops of fruit than do trees in dense stands. This is easily verified by comparing fencerow wild cherries, serviceberries, haws, maples, and other species with those in woodlots. Trees in the open are often loaded with fruit when crowded specimens yield very little. Each year from 1937 to 1939 Michigan State College foresters gathered a bushel of acorns from a large solitary white oak on the college farm. In 1940 the tree bore practically nothing, but such production three years out of four shows what can be expected from the mature, large-crowned trees which develop in situations favorable from the standpoint of sunlight, soil, and water. Such considerations are of the highest importance when we come to planting trees for wildlife.

Good and poor mast years

A better understanding of factors controlling the fruiting of mast trees will permit the wildlife manager to anticipate, and provide against, food shortages in those habitats where deficiencies are most acute. In the sand plains of the north, where the chief dependence is upon jack or black oak acorns, it is possible to predict mast scarcities a year and a half in advance. In areas where a variety of oaks are present, production can be accurately predicted from June on.

The clue to anticipating oak mast supplies (p. 301) lies in the fact that species of the white oak group (those with rounded lobes on the leaves) bear acorns which mature the first fall. Trees belonging to the black oak group (with sharply-tipped leaves) require two years for their acorns to ripen. For the first growing season the fruit of these oaks, the most common of which are black, jack, red, and pin, are represented by small fertile flowers, borne in pairs, at the tips of short stalks on the new growth (fig. 115). The following year the acorns develop rapidly in the same manner as in white oaks. An evident difference in the developing nuts of the

two oak groups is that the one-year fruits have green peduncles, while the two-year kinds have tough, woody stems in the second summer.

The obvious significance of differences in fruiting time among oaks is that factors which cause white oaks to fail may not impair production by black oaks fertilized a year before. Thus in 1939, when all oaks bore abundantly, the spring must have been favorable for pollination of white oaks. But since black oaks also bore well, the spring of 1938 must have been favorable to species in that group. In 1940 everything failed, which means that the spring of 1939 was a poor one for black oaks, and 1940 was not favorable for the whites.

The effective productivity of a tree is, of course, dependent upon other factors than mere fruiting. As an example, the incidence of insect infestation probably varies significantly from one year to the next. That this factor could materially affect the crop is indicated by some figures obtained by J. P. Linduska at Rose Lake in 1941. A random and significantly large sample of four species of acorns showed the following incidence of infestation by acorn weevils: black oak—81%, jack oak—78%, white oak—67%, red oak—7%. Probably such "parasitism" does not completely spoil a nut for use by squirrels—they may relish the larva itself—but it is evident that insects are to be reckoned with. It is also interesting to note that the high tannin content of red oak nuts evidently affects their palatability for insects as well as squirrels.

At Rose Lake it has been noted that the husk of the small-fruited hickory sometimes does not completely open, and this causes the nuts to remain on the tree into the following spring. (p. 247). Large quantities of good squirrel food may in this way be preserved above snow level to be gathered when most needed.

Among oaks there is an alternate-year fruiting periodicity that applies to individual trees (89). Thus a given tree will tend to have large crops every other year, but the *forest* should bear every year. There is a great variability in the habits and characteristics of the fruit among nut trees; and their improvement and utilization may some day yield large dividends. J. R. Smith has given an excellent discussion of the possibilities in oaks (89) and calls attention to the high productivity to be expected from their culture.

Water Requirements of the Fox Squirrel

It is well known that fox squirrels are able to survive on uplands far from any open water. They are often seen to eat succulent plants in the summer, and this is probably their most important source of moisture. On three occasions, in the Allegan area, fox squirrels were seen to drink from a river bayou or puddles. Another was observed eating snow in a tree crotch. P. S. Lovejoy made observations on a litter of young reared in his yard in Ann Arbor in 1940, and although a bird bath was kept constantly filled within a short distance of the den tree, a squirrel was seen to drink there only once. It is probable that the exceptionally fine apples and pears, as well as leaves of violets and other plants, eaten by the animals provided necessary moisture during the summer.

In Missouri, Bennitt and Nagel (15) observed a marked reduction in females and summer juvenile fox squirrels at the time of the severe drought in 1934. The reduction was quite definite among this species, which inhabits the uplands, but was much less marked among gray squirrels of the riverbottoms where water was available. If drought was the determining factor, which seemed likely, moisture must be of greatest importance to nursing females and their broods.

Terrill (95) also found evidence that drought created unfavorable conditions for Missouri squirrels. In the summer of 1936 there was a widespread water shortage, and he observed a concentration of about 200 fox and gray squirrels in 2 acres of woods beside a pond. Evidently nearly all of the squirrels for three miles around had gathered there. Terrill reached the conclusion that in ordinary years there are sufficient succulent plants and fruits to satisfy the fox squirrel's moisture requirements, but that in a year of drought such sources of water are very scant, and surface water becomes a necessity.

There seems to be little question that under some conditions lack of moisture can be a serious mortality factor for fox squirrels. But Michigan topography is for the most part so broken up and interspersed with streams, potholes, and lakes that in this state such scarcities can hardly be more than local. It is known that in the fall of 1935, after one of the most severe droughts on record, fox squirrels were numerous at the Kellogg Farm. But detailed information is not available for the drought years of the early thirties, and there is no certainty what the effects were.

Summary of Chapter Seven

In southern Michigan, staple foods of the fox squirrel are nuts and corn. Mast is used the year around, although it is most important in fall and winter.

Nuts are buried in individual caches at the ground surface, and they can be relocated by scent through more than a foot of snow. Buds are an important supplementary winter food.

Spring and summer foods are left-over mast, insects, green shoots, fleshy fruits, and the seeds of such trees as elm and maple. Nuts are eaten while green, from early summer on. Green earcorn is a favorite in late summer and fall.

Fox squirrels are at their maximum weight in fall and minimum in late winter and early spring. Optimum food conditions permit squirrels to become very fat, and such animals can best survive and breed during the cold winter months. A fat squirrel can remain inactive through periods of unfavorable weather. A thin animal needs to forage and may succumb to exposure or enemies.

The largest supplies of squirrel food come from trees in open situations. Large-crowned specimens growing free from competition bear much larger fruit crops than do trees in dense stands.

Mast failures appear to be caused primarily by weather conditions which prevent the fertilization or development of flowers.

Chapter 8

WHERE HE LIVES

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WHERE HE LIVES

MANY PEOPLE visualize wild animals as living out of doors and hence exposing themselves to extremes of weather. But nearly all of the small animals inhabiting our fields and woodlands provide themselves with well-insulated nests; or they retreat in bad weather into protected places which they are naturally suited to occupy. Most species habitually keep themselves dry and warm; even the muskrat does not get soaked in swimming through the water. Anyone who works with animals soon discovers that a thorough wetting in cold weather is likely to be a serious matter, pneumonia often being the result. The fox squirrel has a wholesome respect for winter storms; and when his belly has been well larded with the unlimited calories of a bountiful autumn, he is content to retire for days at a time to the warm shelter which nature and his inborn behavior pattern have provided.

Fox squirrel nests are of two well-defined types; those built of leaves and twigs in a convenient fork, and hollows in trunks or limbs, For management purposes we should know what the squirrel "can get along with" and what constitutes "ideal housing." Habitat improvement should then be aimed at providing the best nesting facilities practicable in any given type of range.

Leaf Nests

Woodland that is otherwise favorable can support fox squirrels even though it contains no trees large enough to form dens. These conditions are sometimes encountered in cutover woodlands, on farms, and in scrub oak range (fig. 24). Leaf nests, the usual type of shelter in these situations, are extremely variable, and their structure depends upon when and where they are built.

Location and numbers

The fox squirrel may build its nest in a grapevine only 10 feet from the ground, or it may select a location in the topmost twigs of the tallest tree in the vicinity. Leaf nests are not usually placed at extreme heights. In the experimental squirrel woods at Swan

The fox squirrel's nest may be built in a grapevine only 10 feet from the ground.

Creek, 19 of the largest nests averaged 30.1 feet from the ground. In this 40-acre tract the trees averaged 6 to 8 inches in diameter.

In general, squirrels seem to pick the larger trees for nest building. In the sample referred to, the average tree diameter was 10.3 inches. However, these animals have been found wintering in nests less than 20 feet up, and in trees under 6 inches in diameter. In the squirrel woods there was an apparent preference for two species of trees, the white pine and black oak. This was shown by counts made of all nests, large and small. The composition of the woodland was analyzed by making counts of trees and other woody plants above 3 feet in height on 36 one-tenth-acre plots scattered geometrically over the area. White pine was found to compose 2.6 percent of all trees over 3 inches in diameter, but this species contained 18 out of a total of 69 nests located. The remaining 51 were

Fig. 59. Or it may be in the topmost branches of tall timber.

all in black oak, which formed 24.2 percent of the stand. In this woods most of the bulkier nests were placed in the thick tops of the larger pine trees. Others were in large black oaks. Although in 1939 there were no nests in white oaks in the squirrel woods, this does not mean that they are completely passed up. The year before there were at least two in this species.

That conditions in this woods were fairly representative is shown by a random sample taken by Montgomery over a much larger area in 1940. One-hundred twenty nests which he examined averaged 33.8 feet above the ground. Of these, 55 were in black oak, 42 were in white pine, 11 in red maple, 9 in beech, and 3 in white oak. The fox squirrel has an obvious preference for black over white oak in locating its leaf nests. Other species of trees in which leaf nests

Fig. 60. Fox squirrels build nests in many kinds of trees. This one is in a black willow.

have been found are American elm, hard maple, large-tooth aspen, shagbark hickory, basswood, red oak, jack oak, swamp white oak, sycamore, hemlock, black ash, and black willow. They doubtless build in other species, but in Michigan these have not been specifically recorded. In Ohio, Baumgartner found squirrel nests in 22 kinds of trees.

In the winter of 1938-39 there were 69 nests of all sizes and ages in the 40-acre study woods at Swan Creek. In order to find out how many would be built in a season, all old nests were torn out in the spring and summer of 1939. A count in December showed 22 large nests and 14 small structures in the woods. The total of 36 nests was about equal to the number of squirrels *handled* in the woods during the fall, but the nests termed "small" were mere handfuls of leaves and not suitable for occupancy. The number of late summer and fall residents was probably near the number of large usable nests. But in February 1941 there were 15 usable nests and 29 old ones in the woods at a time when only three squirrels were resident, and these were living in a abandoned farmhouse across the road.

Materials and size

A fox squirrel nest is usually composed of twigs and leaves cut from the tree in which it is built (figs. 61 and 62). Ordinarily no other materials are included. Black oak leaves are an especially favored nest material, and they are sometimes used in trees of other species (fig. 63). Nests are occasionally made of pine or hemlock twigs and needles, or they may be composed entirely of the shredded bark of wild grape or large-tooth aspen (figs. 64 and 66). A small amount of grass, moss, or corn husks is occasionally included in nests, but material from the ground is not favored. One nest contained a square foot of old burlap, and another, occupied by a female squirrel on January 21, 1939, was lined with a piece of newspaper dated April 9, 1938. Usually there is no particular lining in a leaf nest. The leaves composing it become frayed and form a soft inner layer.

Summer-built nests are usually made of green twigs with the leaves attached. A rough framework 12 to 20 inches across is laid up, and within it layer upon layer of green leaves are packed in a globular pocket. The leaves dry in place, forming a warm weatherproof shelter; and inside they remain green in color until

Fig. 61. Winter-built nests often have an outer framework of bare twigs.

the following spring. On several occasions after a rain I have evicted a squirrel and found its nest to be dry and warm. The cavity of a squirrel nest is 6 to 8 inches in diameter and usually opens through a hole in the side. Sometimes there is a well-defined opening, but frequently it is merely a loose place in the leaves. The compact portion of a nest varies from 10 to 18 inches in diameter. Often it is an irregular mass bulging from a crotch, with but few accessory twigs to help hold it together.

Winter-built nests can sometimes be distinguished by their construction. The outer framework is a criss-crossed mass of bare twigs, with the nest proper composed of dead leaves laid in a compact cell inside. The twigs in winter nests do not have leaves attached except when white oak, with its persistent leaves, is used.

Fig. 62. Nests built in summer are made of twigs with the leaves attached and present a more bulky appearance.

The inside leaves are brown instead of green, as in summer nests. Later in the year squirrels may clip leafy twigs and add to the structure. Entirely new nests can sometimes be roughly dated, as to time of building, by their appearance. But there is little chance of finding much practical use for the idea, since most large nests are added to from time to time and the original structure may be two or three years old.

Many of the "nests" built by fox squirrels are mere handfuls of leaves placed in a crotch. There may be two or three of these in one tree. They are often built in late summer, and it seems probable that young animals, responding to an urge for cutting and piling, are responsible for some of them. When large enough, such nests may serve as temporary hiding places, but there is usually no

semblance of a cavity, and ordinarily they do not appear to have any use at all. These small "practice" structures, if that is what they are, grade into the large cavity nests, with all types and conditions between. Numerous nests will be found, caved in and rotted, wet inside and unusable. Occasionally a few fresh twigs are added to them, or they may be used as foundations for new nests. Since additions to a nest can not easily be identified without climbing the tree, it is obvious that these old structures complicate the possibility of using nest counts as indices of current populations.

Time of building and durability

Most leaf nests are built in summer when they are difficult to see, and the actual peak of the building season, if there is one, has not been determined. During the cold part of winter such activity is at a minimum, but a few new structures are started in January or February. In several observed cases large nests built in spring or early summer have been torn out during the fall—probably by the squirrels themselves. On two occasions at the Kellogg Farm a fox squirrel is known to have torn out a bird nest. Several of the destroyed squirrel nests were so high in the twigs, so substantially constructed, and then so completely obliterated, that it seems likely the animals themselves were responsible. In one case an individual was known to be occupying a nest in a tree at the edge of a swale, and both nest and squirrel disappeared simultaneously.

Fig. 63. Black oak leaves are a favored nesting material, and they may be used in trees of other species. Many nests in white pine are so built.

Fig. 64. Fox squirrels stripped this large-tooth aspen bark for nesting material.

Fig. 65. A late-winter nest built of tightly packed dead leaves. Summer nests are made of green leaves.

There is fairly good evidence that leaf nests do not offer the protection of tree dens. In the spring of 1940, after a violent wind and rainstorm, a farmer in Scipio Township, Hillsdale County, reported finding 58 young fox squirrels on the ground in his woodlot. This is exceptional, but nests placed high in the small branches are thrashed about severely in a high wind, and a certain percentage of juvenile losses must undoubtedly be charged to the elements.

Use of leaf nests

In the Allegan scrub oak woods many fox squirrels spend the winter in leaf nests. In periods of bad weather they are commonly inactive for two or three days at a time, as evidenced by a lack of tracks anywhere in the vicinity of occupied nests. In late winter, broods of young are also brought forth in these structures, of which some are old and some are newly built. One advantage of this nest type is that it is easily replaced. If it becomes too highly populated with fleas, it can be abandoned and another built. Whether squirrels are capable of so much calculation is not known, but an oc-

Fig. 66. Grape bark makes a soft warm nest. This one was built in early March, 1941.

casional changing to a new nest would certainly have a beneficial effect. The somewhat communal use of leaf nests by different individuals was discussed on page 145 in connection with territorialism.

Hollow Tree Dens

Leaf nests may be built in areas such as riverbottoms, where there is actually an excess of tree dens; but hollows evidently are preferred both for wintering and rearing young. There is little doubt that the provision of suitable dens is an important part of the management job.

Formation

Typical squirrel dens are formed by the self-pruning of forest trees. They are most plentiful in dense stands of old timber, because in this type of growth lower limbs are shaded, die, and break off, leaving openings through which decay organisms can attack the trees. As pointed out by Baumgartner (8) a shaded limb literally starves to death, due to its inability to synthesize food in the absence of sunlight. The living tissue of the trunk, the cambium, grows out around the dead limb in a collar, the limb rots and finally breaks off. On young vigorous trees the scar left by a broken limb usually heals over. But stubs of large limbs on old slow-growing trees may not heal rapidly enough to prevent the end from rotting out to form a cavity. Dead punky wood is removed by woodpeckers or the squirrels themselves as decay penetrates into the tree trunk. Squirrels habitually gnaw the entrances to their dens, as well as branches and twigs in the vicinity. When the entrance hole heals to an opening about three and one-half inches in diameter, the animals maintain it at that size by gnawing back each season's growth. Thus each year a new layer is lapped over the scar of the year before, and these are good evidence of the minimum time the den has been used by squirrels. It is common to count five or six heal scars on a den entrance (figs. 68 and 70) and Baumgartner counted one den with nine (8). It is a curious fact that squirrels will gnaw the edges of tree wounds after they

Fig. 67. Freshly-gnawed entrance to a den in red oak.

Fig. 68. Gnawing by generations of squirrels has kept this elm den open and left many heal scars.

Fig. 69. This hickory cavity has been filled with water by trunk drainage and cannot be used as a den. Hickories form few good dens.

are healed past all possibility of the animal entering. Whether or not they eat this bark is unknown. Figure 71 shows where a limb was shed about 18 years ago and where the squirrels have cut away each year's accumulation of wood to such an extent that a scar was formed. The center is now rotting out and it probably will become a habitable den. Work of this kind, like apparently indiscriminate nest building, suggests that, within the limits of their abilities, squirrels have a somewhat random pattern of behavior resulting in both productive and unproductive effort. Whether trial and error explains it all would be too much to say on a basis of present evidence.

Not all dens are formed in the way described. Woodpecker holes are often used as temporary retreats, and in rotten stubs or limbs where they are large enough, they serve like other dens. In the Allegan area hollow pine, aspen, elm, and red maple stubs were used, with good evidence that the cavities began as woodpecker holes. The flicker, especially, hollows out excellent squirrel dens in decaying wood.

Injuries to trees resulting from storms often result in good squirrel dens. Where water can collect in the hole, decay is accelerated and may penetrate well into the trunk. However, cavities into which water can drain, such as the one in fig. 69, are suited to little other than mosquito larvae. The cavities left by broken branches often have entrance holes large enough to admit a raccoon or barred owl. These are sometimes used by squirrels, and occasional mortality of nestlings probably results. Where a tree is completely split apart a fox squirrel may pack the cavity with leaves and twigs and make its nest within. Large hollow trees which are open at the bottom provide excellent hiding places, but such trunks are not ordinarily used as dens.

Open-grown trees produce more food than forest trees, but their lower limbs do not usually die and form so many hollows. An old woodlot white oak is an ideal den tree. Its dead limbs retain their bark, absorb moisture, and rot quickly. Black oak forms but few dens, since dead limbs slough the bark, become hard and brittle, and rot slowly. Hickories also form few cavities; and when they do, squirrels seem to make little effort to keep them open. In river bottoms soft maples are particularly subject to storm damage and rot readily, forming numerous hollows. Elm and sycamore are excellent den trees. In beech-maple woodlands both species form cavities, but beech is notable in this respect. From a management

standpoint the trees which produce the most and best dens are white oak and beech in the upland, and elm and red maple in the lowland.

Use of tree dens

There is no doubt that tree dens give squirrels more protection from weather, natural enemies, and man than do leaf nests. Hence this is the sort of housing which a long-time management program should aim to provide. In a den cavity with a small opening a fox squirrel can spend the stormy days of winter in warmth and safety. It can rear its young without molestation by raccoons, housecats, or cavity-inhabiting owls, and it has a place of retreat from hawks and bullets.

It is the common habit of squirrels to stuff a large nesting cavity full of leaves—black oak leaves preferred. This is probably a regular procedure in the fall and again before the young are born in late winter or spring. However, in the riverbottom at Swan Creek two litters were found in cavities with large openings and with no lining except rotten wood. The leaf padding reduces large cavities to squirrel size, and improves insulation, but it also delays drying when snow or rain comes through the opening.

Fig. 70. The ideal den tree is the white oak.

Fig. 71. For eighteen years the squirrels gnawed back each season's growth. Rot has entered and this will soon be another white oak den.

There is one record from the Allegan squirrel woods which indicates that a particular squirrel may occupy a tree den for most of its life. In October 1937 a female (probably a spring juvenile of that year) was marked at the southwest corner of the woods. This animal was taken more than thirty times in this vicinity and was repeatedly tracked or followed to a red maple growing just outside the woods. In 1938 the animal was seldom handled, but in 1939 it is known that this squirrel bore one litter of young, and probably two, in a hollow crotch of the tree. In 1940 another brood was brought forth in the same place. The squirrel died in 1940, and evidence is good that it regularly used the one hollow for three years, although it was also known to frequent a leaf nest 100 yards distant. In 1939, as late as December, at least one of the summer litter was also using the cavity.

Tree dens may or may not have leaf nests associated with them. There were several long-used hollows in the Swan Creek area which had no leaf nests in the immediate vicinity. In other cases, large or small nests were built in the same tree.

Fig. 72. Trees grown in the open do not shed their lower limbs. There is little chance for rot to enter, and they form few squirrel dens.

Tree cavities have certain disadvantages not found in leaf nests. A new one cannot be built at will. They are excellent centers for the hatching and dissemination of fleas. It is not uncommon to find a den opening ringed with fleas on the inside, apparently waiting to welcome any squirrel caring to enter. Squirrels occasionally die in these cavities and render them unsanitary for some time thereafter. Actually, this does not seem to bother the animals, as they may rear their young on top of a putrid carcass oblivious to the stench. Possibly the changing from one den to another, or to a leaf nest in summer, may help to maintain the cavities in a passable state of sanitation. A recently lined nest is usually dry and clean.

The chief competitors of the fox squirrel for tree dens are, red squirrels, raccoons, flying squirrels, woodmice, screech owls, barred owls, wood ducks, starlings, and bees. The size of the den opening largely determines what animal will be successful in such competition. Montgomery witnessed the killing of a black squirrel by bees after it had entered a hole occupied by the swarm. In 1941 Stuewer found several raccoon scats containing fox squirrel hair in nest boxes which had been used by both species. This is poor evidence, as the squirrels may have been animals which had died in the severe winter preceding; but it would hardly be "according to nature" if a raccoon entered a hollow containing a litter of young and did not take advantage of the situation. On several occasions woodmice have been found in abandoned leaf nests high in the treetops, and hunters have told of shooting raccoons out of large squirrel nests. A crow or hawk sometimes uses the leafy abode of a fox squirrel as a base for its own nest, but most competition for nesting sites doubtless involves den cavities.

Fig. 73. This American elm den was very shallow. Although somewhat exposed, a brood of young was successfully reared here in the spring of 1939.

Fig. 74. This cavity has an opening large enough to admit a raccoon or owl. Fox squirrels probably lose some litters in such places.

Fig. 75. Woodpeckers make dead stubs habitable for fox squirrels.

Summary of Chapter Eight

In general, fox squirrels use two types of nests: those they build of leaves and twigs in a tree fork, and hollow tree dens.

Black oak leaves are the favorite nesting material, although leaves of other trees and bark are also used.

Fox squirrels habitually gnaw the entrances to tree dens, and this keeps the holes from healing shut.

Trees growing in dense stands contain the most dens because limbs are frequently shaded and die, and on old specimens these do not heal quickly, permitting rot organisms to enter the trunk.

White oak and beech form the best hollows in upland timber, and elm and red maple are particularly good in bottomlands.

Tree dens protect squirrels and their young from enemies and from the rigors of winter weather. Provision of such nesting facilities should be one of the aims of management.

Chapter 9

THE HUNTER'S COMPETITORS

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THE HUNTER'S COMPETITORS

MORTALITY FACTORS affecting any animal must be judged according to how great the losses are from each cause and at what season they occur. To determine what agents are most important in this respect is difficult and largely a matter of weighing all evidence and then reasoning it out. There is no known method of accurate measurement.

It is likely that the annual harvest of more than half a million fox squirrels taken by Michigan sportsmen represents the greatest mortality which can be charged to a single factor. It is, however, the "losses" due to things other than hunting with which we are here concerned. The whole program of increasing game reduces to the proposition of so controlling the environment that non-hunting-season mortality will be minimized. In effect this means supporting a high breeding population and then utilizing the natural fecundity of animals by transferring losses ordinarily chargeable to other causes to the hunter's bag.

One of the best clues to mortality is the examination of the animals themselves for evidences of disease, parasitic infection, injuries, abnormalities, and general condition. This has been possible in the Michigan studies since many squirrels have been box-trapped and tagged. Another source of evidence is the actual observation of kills in the field, or the finding of remains with tracks in the snow or other indications of what happened. A third approach is to study the food habits of animals associated with squirrels, particularly those which can be expected to use them as prey. Although we can not say that any given cause is responsible for a certain percentage of squirrel losses in Michigan, nevertheless a fairly good conception of the whole picture has been obtained.

Food Scarcities

From 1937 to 1941 food supplies played an important part in determining squirrel populations in the scrub oak habitat in Allegan County. In 1937 and 1938 there were "fair" crops of oak mast in the uplands, and during both years squirrel numbers increased.

In 1939 there was the greatest abundance of mast occurring in five years, and in 1940 the population probably reached a high for the same period. But the complete failure of the 1940 acorn crop precipitated a crisis in the ensuing winter. Among fox squirrels handled there were many signs of malnutrition and weakness. Through winter and spring 16 individuals were found dead in natural dens, and in wood duck and raccoon nest boxes. Five more were found on the ground. In addition, a gray squirrel and two flying squirrels were recorded as mortalities. Mange was widespread among fox squirrels during the winter months, and those autopsied were 3 to 8 ounces under the average weight for late winter the year before.

Some details recorded by Montgomery (76) indicate how acute the situation was. Only three fox squirrels were using the study woods, and they were living together in a large leaf nest in the attic of a deserted house across the road. Only one of these animals came out regularly to forage for food, another came out twice on mild days, and the third did not come out at all. The latter was found dead, evidently of starvation. Another squirrel was discovered moving sluggishly through the woods and was taken to the

Fig. 76. A food scarcity plus a hard winter is a lethal combination in the northern half of the lower peninsula and farther south in scrub oak habitats. Malnutrition results in emaciation and appears to favor the spread of scabies. In the Allegan area many squirrels were found dead in the winter of 1940-41.

Fig. 77. In farmland, food scarcities are less acute than in submarginal scrub oak habitats. In agricultural land mixed woodlands produce more consistent foodcrops; and when mast largely fails, field corn near woodlots tides the squirrels over.

laboratory, where it died in convulsions. It was emaciated and mangy, and records showed that its weight had declined from 1 pound 12.5 ounces in July to 1 pound 4.5 ounces in the following January.

The foregoing observation of ailing fox squirrels denning together has been recorded several times. In the raccoon boxes referred to, a group of five animals was found, including an old female, a yearling male, and a yearling female. The other two escaped. All were covered with mange, very thin, and lacking vigor. With two or more dens within 20 yards of the nest box, these animals were together—possibly gaining warmth, but probably also contributing to the spread of the mange mites.

In addition to causing the death of individuals directly, food scarcity further reduced the population by preventing breeding (p. 107). An increase in the pathogenic effects of scabies (mange) and susceptibility to shock (p. 215) appeared to accompany malnutrition and may have resulted from it. That the winter die-off of squirrels in 1940-41 probably was widespread in scrub oak habitats of the state is evidenced by conditions found in Lake County sand plains (p. 89) and also by decline in the statewide kill of 1941 (p. 59). The better food conditions existing in farmlands have been discussed.

Winter Weather

Several of the most important mortality factors affecting fox squirrels are difficult to evaluate individually. The reason is that they do not work individually. This is particularly true of food

scarcities and severe winter weather. Mast failures in the fall cause the animals to be emaciated and less able to withstand exposure. In addition, ice and snow on the ground may render buried nuts less available, thus causing a food shortage. Lack of food evidently lowers the resistence of squirrels to scabies, and the consequent loss of hair renders them more susceptible to exposure. The merry-go-round is complete when it is pointed out that any or all of these weakening factors may make it easier for a dog, hawk, or owl to dine upon squirrel.

In Michigan the fox squirrel is on the northern border of its range, and the farther north it goes the longer and more severe the winters are. Whether or not squirrels survive depends upon their condition and how long unfavorable weather lasts. The winter of 1935-36 was the most severe on record, and the squirrel population at the Kellogg Farm (and no doubt all over the state) declined. The scabies epidemic, the most obvious factor to which this could be attributed, was undoubtedly aggravated by the hard winter. And the comparative scarcity of oak mast in the fall of 1935 also contributed to the situation.

The harmful effects of hard winters have been observed in other states. Terrill (95) described a sleet storm in Missouri which resulted directly in the death of many squirrels. Shifting winds caused the trees to become thickly coated with ice on all sides. When squirrels descended to the ground to forage, they were unable to climb back up again. Many animals died of exposure and starvation, and those which survived were in poor condition to breed. "The first brood of young squirrels following the winter was extremely small. Very few were seen during the spring and summer of 1937, though they began to appear in the fall in numbers described by observers as 'fair to poor.' "

Goodrum (44) observed the effects of hard winters in Texas: "Probably severe winter in this section reduces the number of breeding females. Such a reduction was reflected in the small crop of young following the continued cold of 1936." These statements recall strongly observations made during the past few years in Michigan.

Disease and Parasites

Probably it is significant that among cyclic animals those causes of "lows" which have thus far been satisfactorily demonstrated are diseases. The peak in numbers among Norwegian lemmings (24), meadow mice (39, 52), and snowshoe hares (48, 71) is followed by a period when disease decimates the population. Human plagues have also been most destructive under conditions of high population density. Many diseases and parasites are present at all times among the species they affect, breaking out as epizoötics when numbers are high and/or conditions in the environment (such as war or a food scarcity) lower the vitality of individuals. There is evidence that this point applies particularly to the fox squirrel.

Scabies

Mange, or scabies, has been mentioned several times. This disease has been found to be so common in Michigan that it is surprising so little notice has been taken of it in the past.

Fig. 78. Sarcoptic mange (scabies) appears to be the most serious natural mortality factor among Michigan fox squirrels. The disease may be complicated by conditions other than just the infestation of mites.

S. C. Whitlock

The first mention found in the literature was in *California Fish and Game* in 1922 (87, 93). From that source, a note on a malady affecting tree squirrels of the Trinity section of Shasta National Forest reads, "It seems to be a kind of scab and it takes away all their strength, as they are unable to climb or make any time on the ground." Another report concerned the gray squirrel in the Klamath National Forest: "It is reported that a disease breaks out every few years among the squirrels on the lower Klamath River, which reduces their number considerably. In instances observed, small red spots appear on the skin; the hair comes out in large patches giving the appearance of mange. Specimens observed have been very emaciated."

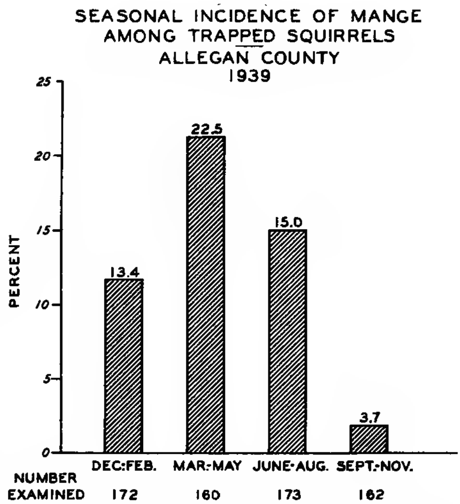


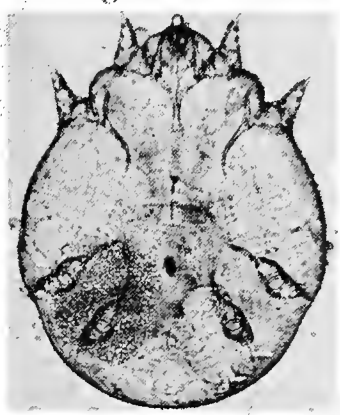
Fig. 79. In most winters scabies becomes noticeable in late December and January. It increases markedly during the period of greatest food scarcity in late winter and reaches the maximum in early spring. By hunting season practically all squirrels are free of visible indications of it.

Similar observations have been made in Wisconsin, as Errington mentions finding a nearly hairless fox squirrel dead in the woods, and he collected a number of ground and tree squirrels "afflicted with a mange-like skin disease" among the prey items at nests of the red-tailed hawk (36). There have been remarkably few references in the literature to what evidently is the same condition reported by many people in the past few years from every portion of this state where squirrels are numerous.

At the Kellogg Farm, in late winter and spring of 1936, numerous squirrels were seen with patches of hair missing, some appearing almost "naked." Several animals were found or reported dead on the ground or in bird nest boxes around Gull Lake. In the following winter the population was found to have declined somewhere between 30 and 50 percent. This was the first indication that scabies might be an important cause of death among these animals in Michigan.

At Swan Creek, from 1937 to 1942, it was found that scabies appeared every year in December and January, reached its maximum in March and April, and declined through spring and early summer to a minimum in late summer and fall. In 1939 a good sample of the population was handled in all four seasons, and the percentage of conspicuous scabies infections is shown in fig. 79. In the fall a squirrel seldom is found in which the condition is noticeable. From the sportsman's standpoint it is fortunate that his game is in its best condition during the hunting season.

This hairless condition in squirrels is usually associated with an infestation of the scabies mite *(Sarcoptes scabiei)*.[22] This almost microscopic creature (not an insect, but a relative of the spider) burrows in the skin causing hair to fall out and scabs to form. The disease has not been studied intensively in squirrels, and there is no certainty whether it is merely a matter of infection by mites, or whether there are several associated factors involved. From the seasonal aspect of the condition it is possible that the diminution of foods, vitamins, sunlight, or other factors in the environment may help to "soften" the squirrel for the mites to take over. The two most acute epidemics of scabies came in winters when the population was high and food supplies were low, (1935 and 1940). It is probable that both malnutrition and the closer association of individuals aggravated the situation.



Photomicrograph by Virginia Stoney and L. C. Hulbert

Fig. 80. The scabies mite (*Sarcoptes scabiei* subsp.). This animal is not an insect, but a relative of the spiders. It burrows beneath the skin of its host and appears to be the principal cause of the mangy condition common in squirrels. The mite is barely visible to the naked eye.

In many squirrels the disease appears first on the ears. The tip and rim of the ear become bare and dark. This is followed by swelling and the appearance of scabs and sometimes

[22]Identified by S. C. Whitlock of the Game Division pathology laboratory.

Fig. 81. Scabies usually becomes noticeable first on the head and ears. The animal scratches, and scabs and pussy lesions form.

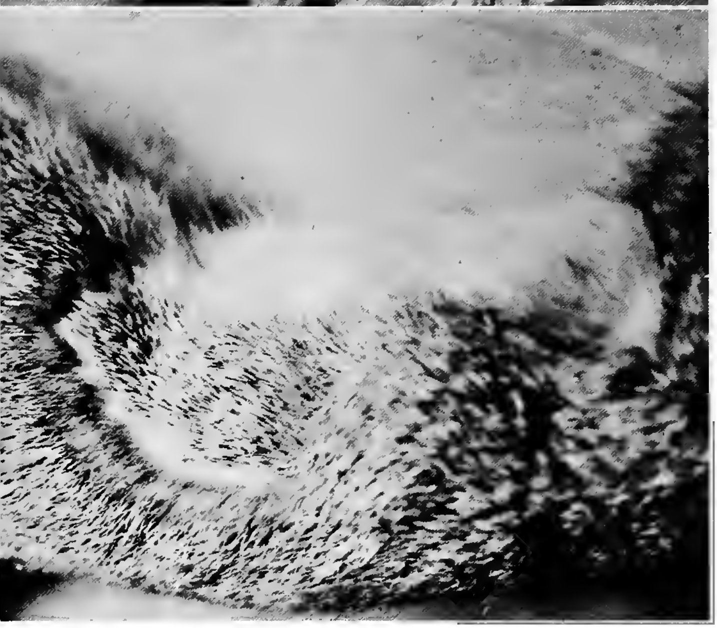


Fig. 82. Ordinarily most animals recover from the mangy condition. This specimen had a new growth of hair coming in.

pus. In severe cases the crease between the ear and head becomes an open sore, and the ear may be drawn down and stuck flat to the head. In other cases a spotty hairlessness occurs over the body (fig. 81), or the animal may lose practically all its hair. The skin is commonly covered with scabs and often becomes pigmented. It is evident that much itching is produced, as the animals scratch vigorously and further complicate matters with their sharp claws.

There are known examples where animals with more than half the body bare (fig. 78) grew a new coat and completely recovered. But there are more than twenty mortality records of the past few years in which evidence pointed to scabies as the primary cause of death, and in many others it was doubtless a contributing factor. On three occasions animals with evident mange were found weak and unable to climb and were easily caught by hand. Another with an extensive infection was taken by a dog (fig. 83). E. C. O'Roke of Ann Arbor found four squirrels with extensive mange at a fox den. Montgomery described a scabby squirrel in which the musculature of the hind legs had deteriorated. Mangy animals frequently died in box traps, from exposure, or convulsions due to shock. These indications, especially in the light of Errington's record (36) of "Three out of five arboreal squirrels, two out of two Franklin ground squirrels, and perhaps one-third of 42 striped ground squirrels . . ." found in a mangy condition in hawk nests, suggest strongly that a weakening ailment such as scabies causes much mortality by rendering effective such secondary agents as natural enemies.

Another of these agents certainly is cold weather. Scabby squirrels were found to average 1.35 ounces less in weight than healthy ones, emaciation regularly accompanying the hairlessness (7). Squirrels with little hair and no belly fat can not remain inactive for long during the winter, and must expose themselves to severe weather by foraging for food. The fact that mangy animals are frequently found dead in nests suggests that they sometimes weaken and die with little attempt to better their condition. Others get out but do not have the strength to climb back again.

Some experimentation has been done with captive squirrels. A female with a slight infection evidently transmitted it to a litter of five (three her own and two from a hollow tree), and all of them died. On June 7 a squirrel placed in a nest box with the carcass of another which had died of scabies began to show scabs by July 1 and was dead on August 22. On July 13 a healthy squirrel was placed in a nest box from which a scabby squirrel had just been removed. It developed a few signs of scabs around the ears, but never became any worse than that. Montgomery infected a squirrel artifically on March 24 and it died on May 30. These captive animals developed cases of scabies similar to those in the wild. They had excellent nesting logs and plenty of food, but in late winter and spring they contracted the disease readily and died. The origin of some infections was not known. In the spring of 1941 five penned

captives died of this condition. Beyond these fairly good indications that the mites can be transmitted by contact, or even by the use of a recently-occupied nesting hollow, little is known. We can not run our squirrels through sheep dip, and we can not disinfect lower peninsula tree dens. Experience with all species of animals, including man, indicates that when populations become too high epidemics are the rule. So it may be that even good squirrel habitats will not be free from such decimating factors. It has been observed, however, that a fat squirrel seldom shows signs of scabies. In 1940-41 the disease was much less common at Rose Lake, where squirrels were in good condition during the winter, than among the starving animals in the Allegan oak grubs. This may seem inconsistent with the idea that well-fed penned animals in late winter were susceptible. Perhaps, again, it is *going into* the winter in good condition that counts. At present there is nothing to do about scabies, except to learn everything possible concerning it, and in the meantime to manage our squirrel range for the best possible food conditions.

Fig. 83. Scabies seriously weakens squirrels and probably renders them more vulnerable to their enemies. This one, still warm, was taken from a dog.

Shock

Early in the squirrel work it was discovered that trapped animals which were being handled would sometimes become dazed, go into convulsions, and die. The whole process might take an hour, or the animal might live for a day. Squirrels in traps would occasionally be found in a comatose condition.

With only imperfect ideas of its exact nature, this type of affliction in squirrels has been commonly referred to among field workers as "shock." It has been observed in cottontails, and probably in field mice. Green and his associates have made an intensive study of "shock disease" in the snowshoe hare in Minnesota (47, 48). Their account suggests strongly what has been observed in the fox squirrel in this state. Montgomery has given an excellent description (75):

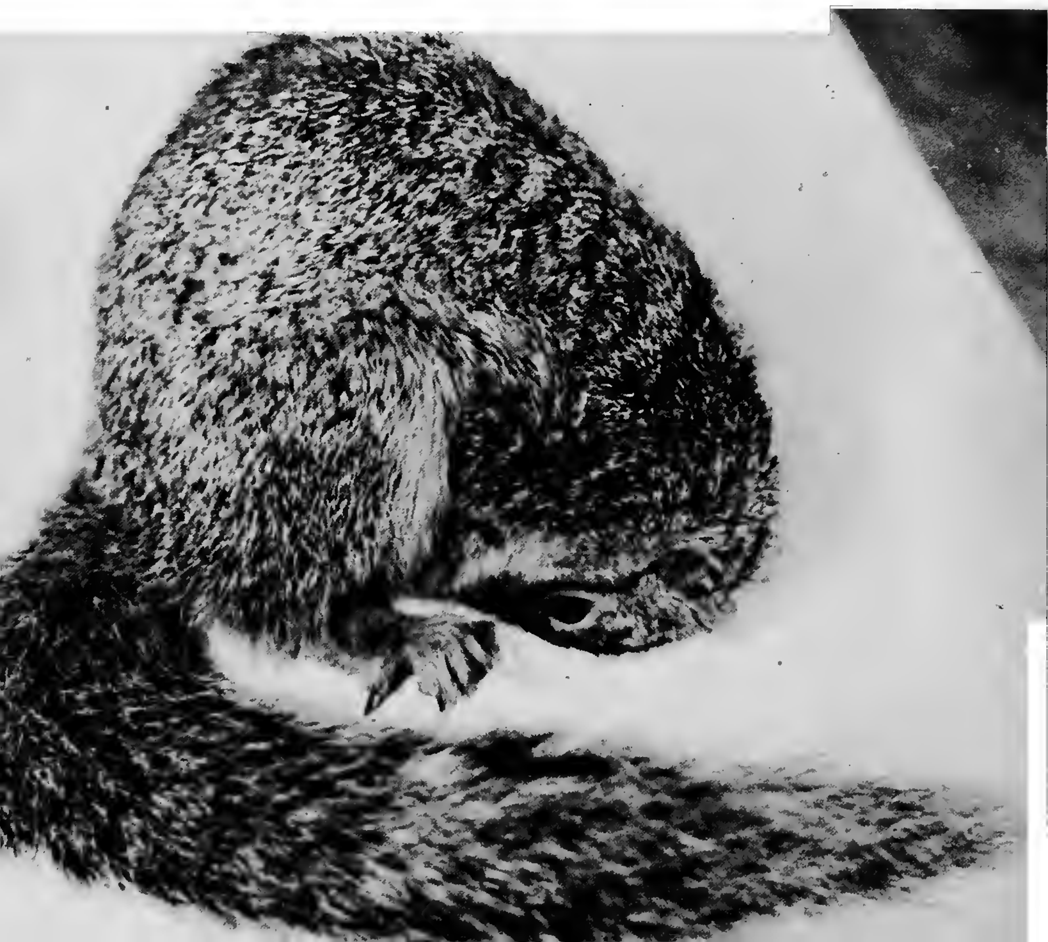
"Early symptoms of shock include excited efforts to escape from the trap, followed by lethargic repetitious movements around the trap. At this time, it is very difficult to get such a squirrel into a cone, whereas a normal squirrel would enter a cone within a few seconds. In later stages, squirrels suffering from shock assume abnormal positions which appear to be characteristic. In one position commonly seen, the squirrel sits on its hind feet with head tucked down beneath the body, almost out of sight between its hind legs. Most severe of shock convulsions causes the squirrel to arch its shoulders; the front feet extended forward and out; while the hind legs are extended to the rear. All muscles in the body appear to be tensed. In this position, the animal frequently rolls over and over in the trap, or remains 'frozen' in the same position for several minutes. Death usually results in 3 to 24 hours."

Fig. 84, a photograph of a squirrel trapped at Rose Lake, well illustrates one of the characteristic shock positions described. Green ascribed shock in the snowshoe hare to a degeneration of the cells of the liver and a shortage of blood sugar (hypoglycemia). He found that dextrose injections beneath the skin would allay the symptoms. Montgomery found that this treatment had a similar effect on squirrels. After the sugar injection the convulsion ceased and the animal returned to an apparently normal condition. L. C. Hulbert brought several squirrels in shock from a Michigan State College woodlot to the Game Division pathology laboratory where S. C. Whitlock examined them. Blood sugar analyses showed a hypoglycemia. Two specimens injected with dextrose and returned

to the woods were later retaken in the traps, indicating a complete recovery. Among the squirrels examined there has been no evidence of an actual degeneration of the liver.

The exact significance of shock as a cause of mortality is not known; but like scabies, it may contribute to the effectiveness of other factors. Two field men at Rose Lake surprised a squirrel in an open fencerow and were pursuing the animal toward the woods when it suddenly rolled over helpless on the ground in shock convulsions. A squirrel caught by hand in the Swan Creek squirrel woods showed symptoms of shock as well as scabies. It seems logical that if these animals react in such a way to handling or pursuit by man, they might be subject to similar seizures when suffering from exposure or attempting to escape from an enemy.

Fig. 84. A squirrel in a condition of "shock." Trapped fox squirrels sometimes go into convulsions and die. The condition is especially likely to occur while they are being handled and is associated with a deficiency of blood sugar. Squirrels have been found in the wild in what appesred to be shock convulsions, and it probably is a supplementary mortality cause of some importance.



Other parasites

Aside from the scabies mite, fox squirrels in Michigan have been found infected by two other species of mites, two species of fleas, two kinds of lice, and an unidentified tick (7, 77). Fleas are by far the most noticeable of external parasites and are troublesome in the nest boxes of captive animals. Fleas are also often found in leaf nests and dens, and they help in the course of field work to determine whether or not such are being used. Bot fly larvae are known to infect squirrels at times, but none has been found in Michigan fox squirrels.

The internal parasites reported for the species include tapeworms, round worms, protozoa, and bacteria (63) such as are usually found in rodents. Little study has been given to parasites of the fox squirrel, but there is no evidence that any but the scabies mite is an important source of mortality in this region.

Natural Enemies

When a fox squirrel is on or near its den tree, it probably is comparatively safe. Its boldness in the open, however, occasionally proves its undoing. In two instances I have seen healthy animals in open fields, cut off their retreat to the woodland, run them down, and caught them. This is one of our best clues to the vulnerability of the fox squirrel to its enemies. One record was obtained at the Kellogg Farm and one at Swan Creek of a red-tailed hawk rising from the ground near a woods with a fox squirrel in its talons. In 1938 a fresh skull was taken from a redtail nest in the Allegan area. At Rose Lake, squirrel remains were found at a nest of this hawk. In the Kalamazoo River bottom an osprey was also seen carrying a fox squirrel. An Augusta, Michigan, trapper told of taking nearly an entire fox squirrel from the stomach of a large hawk. There are also reports in the literature which indicate that these animals occasionally fall prey to the larger hawks (34, 36).

Since most owls hunt at night, they do not often catch fox squirrels. No evidence of horned owl predation on squirrels has been found at either of the wildlife experiment stations. In their comprehensive report on the great horned owl and its prey, Errington and the Hamerstroms (38) recorded fox squirrel remains in only 20 of 4,815 pellets and 23 stomachs from Wisconsin and Iowa. As

they pointed out, the activity periods of the squirrel and horned owl do overlap occasionally in late evening and early morning, and it is probable that some squirrels are picked up at these times. Animals weakened by lack of food or disease, as in some cases already cited, may not be able to return to the nest and thus are exposed after nightfall. Healthy squirrels, sick squirrels, and dead squirrels, all are taken by predators, and all leave similar traces in pellets and droppings. Where such traces are plentiful, one needs to use care in his interpretation; but where evidence is largely absent, as in the case of the fox squirrel in horned owl food remains, it is reasonably good proof that few are taken.

At both Swan Creek and Rose Lake it has been a regular procedure each year to collect food items from nests of predatory birds, and to confine nestlings for further collections after they would naturally have left the nest. On May 5, 1939, a three-weeks-old fox squirrel was found among the crayfish, mice, and other items at a barred owl nest in the Kalamazoo River bottom. This young animal lacked two weeks of having its eyes open and must have been taken alive from the nest, as it had been grasped by the back and killed by a blow of the bill on the back of its head. It is interesting to note that Errington (35) recorded a juvenile fox squirrel and two juvenile squirrels provisionally identified as grays in the food remains at a barred owl nest. It probably is significant that, contrary to the usual habit of the horned owl, the barred species inhabits hollow trees, where it might chance upon a litter of young squirrels.

The possibility of raccoons preying upon young squirrels in large hollows has previously been pointed out, although direct evidence is lacking. Baumgartner (11) found fox squirrel remains at 4 out of 7 fox dens, indicating that these animals may be fairly successful at catching them, although Dearborn (28) found few traces in either the fox or raccoon food specimens examined by him in Michigan.

Among mammal predators of the squirrel the dog is probably of greatest importance. Wherever dogs run loose (and where not?) they hunt rabbits, squirrels, and other animals unremittingly. Four certain records, and much more circumstantial evidence, of squirrel kills by dogs have been obtained during the several years of work in this state, and Terrill (95) obtained similar evidence of predation by dogs in Missouri. One occasionally hears of domestic cats catching young squirrels also, but no precise information is at hand.

L. C. Hulbert

Fig. 85. Malocclusion in the fox squirrel. The upper skull is normal, showing the sharp incisors. In the lower skull the incisors failed to meet properly and were not sharpened by wear. This animal was very thin and would probably have died during the winter.

Records of squirrel predation have been so few, compared with the amount of work done and with the numbers of other animals found, that the conclusion is inevitable that in Michigan this species does not furnish an important article of diet for any of our carnivorous birds or mammals. The fox squirrel has few young, it takes good care of them, and the adults have excellent means of escape from natural enemies. There is little need for concern about the importance of predation to the supply of game squirrels in Michigan.

Highway Mortality and Accidents

In Michigan dead fox squirrels on the highway are a common sight. In the first two years of work at Swan Creek, 23 specimens were picked up in the vicinity of Allegan and the experiment sta-

tion. Reports of 49 Conservation officers in the southern half of the lower peninsula show that in 1941 they observed 1,422 fox squirrel kills on highways, as compared with 4,911 rabbits, and 3,712 pheasants. Squirrels often have their nests in trees along roads, and such fencerow trees often fruit plentifully, attracting animals from some distance around.

Fox squirrels are remarkably free from accidents. A fall from the treetops bothers them little. When nests are examined, their occupants will unhesitatingly launch themselves into the air from a height of 35 or 40 feet, hit the ground with a thump, and run away unharmed. A third-grown squirrel, upon being pursued to the topmost branches of a riverbottom elm, leaped 70 feet to the ground. It was caught uninjured, and lived for many months in the pens at the Swan Creek station. In leaping, these animals spread legs and tail so that air resistance in some measure helps to cushion the fall. They hit the ground flat on the belly and are capable of sustaining a hard impact without harm.

Among all of the animals handled in box traps, no fox squirrel has ever been found with a serious injury resulting from an accident in the wild. At Rose Lake a specimen was electrocuted when lightning struck its den tree, but this, of course, is unusual. Occasionally abnormalities such as malocclusion (fig. 85) are found, but in terms of annual mortality these are of little significance.

Where the Squirrels Go

Probably about two-thirds[23] of Michigan's fox squirrels die in an ordinary year (p. 100). On a basis of present knowledge approximately half of these are taken by hunters. It is not unlikely that half of the remainder (one-sixth of the population) die of scabies, exposure, and other disorders basically associated with local food conditions, bad weather, etc. The remaining sixth of the population may be accounted for by highway kills, predation, accidents, and other causes of lesser importance. These estimates are based upon population changes in the study areas, measurements of hunting kill, and observations on natural mortality.

It seems evident that the more plentiful squirrels are, the more they will compete with one another for food and den sites, the more

[23]This estimate is made with the potential increase of the overwintering population as a basis. It includes losses to the breeding stock and losses of young animals both before and after they are born.

easily disease and parasites will spread, and the better hunting will be enjoyed by such predators as dogs and hawks. Most of these factors are most effective in the winter season. Hence the hunting season comes at the best time of year for the sportsman to thin the fox squirrel ranks and thereby reduce natural mortality.

Summary of Chapter Nine

The critical season of the year for Michigan fox squirrels is winter. The winter of 1940-41 showed that a failure of the mast crop was the fundamental cause for widespread mortality and failure of squirrels to breed in scrub oak range.

Malnutrition was associated with an outbreak of scabies. This disease is characterized by an infestation of mange mites and is most prevalent when populations are high and squirrels are in poor condition. The percentage of infection is greatest in late winter and spring, and least during the fall.

Squirrels handled in box traps are occasionally afflicted with shock—a condition apparently induced by a shortage of blood sugar. Malnutrition, scabies, and shock may all contribute to the ill effects of cold weather and render the animals more vulnerable to natural enemies.

Bird and mammal predators are not important causes of fox squirrel mortality in Michigan.

All evidence suggests strongly that when squirrels are abundant it contributes to the productivity of the population to thin them out in the fall by heavy hunting. This probably is the simplest way to transfer some of the yearly natural losses to the hunter's bag.

Chapter 10

THE FOX SQUIRREL'S GREEN PASTURES

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THE FOX SQUIRREL'S GREEN PASTURES

HAVING REVIEWED the history and habits of the fox squirrel in Michigan, we should now have a fairly clear-cut idea of what the species needs to live well and reproduce plentifully. It should be possible to assemble specifications for an ideal habitat. These will approximate the wildlife manager's formula: his recipe for abundance. The word "approximate" is the correct one; for it will be necessary to subtract or add an ingredient from time to time, or to change the proportions of those which are proved effective.

Such a description needs in some measure to be drawn to scale. So it will be understood that these discussions deal in terms of a few hundred acres of land. They concern those things in the immediate environment which an animal utilizes in the everyday course of earning his living and begetting his kind. Of necessity, such specifications must apply to our state alone. Considering its entire range,[24] the fox squirrel may find truly optimum living conditions far south of Michigan.

The Ideal Habitat

The discussions of squirrel numbers and habits have brought out several points which help in determining the characteristics of a good habitat. It has become evident from work of the past few years that nearly any of the four main woodland types—scrub oak, oak-hickory, beech-maple, or floodplain forest—may at times support a high fall squirrel population, that is, an animal or more per acre. Scrub oak might be considered the poorest of the four types, and yet in the fall of 1942 Allegan County oak woodlands were well stocked with these animals, and hunters enjoyed the best shooting in many seasons. What is the principal characteristic that makes one habitat less favorable than another?

It seems to be year-to-year variability. None of the habitats studied has exhibited a uniform productivity, and the instability of squirrel populations has been particularly evident in scrub oak range. The most evident fluctuating factor which might account for this is food supply.

[24]For a range map of North American fox squirrels see Seton (86).

Optimum food conditions

Michigan studies support the conclusion that, presupposing a favorable forest pattern, consistent food productivity is the most significant characteristic of good fox squirrel range. Adequate nutriment and good body condition favor the species in three primary ways: (1) They minimize winter activity, thus contributing to the security of individuals. (2) They increase resistance to disease and parasites. (3) They aid bearing and rearing of young in the midwinter breeding season. The chapter on feeding habits showed what conditions contribute to the production of staples upon which the fox squirrel depends.

Open-grown mast trees: The relationship between sunlight and mast yields has been particularly stressed. It was shown that the seed crops of trees growing free from competition are much larger than those of woodlot (crowded) trees. Heaviest mast production is by trees standing in the open. Next best are those on the edge of the woodlot. It is to be expected that an ideal fox squirrel habitat will consist of fairly open stands of trees with numerous large-crowned specimens growing near the woods margin.

Variety in the woodland: Composition of the woodland also has an important bearing on food supplies. If the trees bore every year, a fox squirrel probably could want nothing better than an oak woods. But since there are periodic failures of the seed crop in any one kind of tree, the more species that are present in a given locality the more likelihood there is that some sort of food will be present in quantity in any given autumn. An oak woods is not so *consistently* good squirrel range as oak and hickory, and it is logical that the latter is still better if it is varied in spots with maple, elm, beech, walnut, hazel, and other woody plants. There is little doubt that in Michigan this oak-hickory-plus type of woodland represents the most reliable combination for fox squirrels.

Field crops and fencerows: Corn has been listed as one of the fox squirrel's staple foods. It is of particular value when mast supplies are low and doubtless helps farm woodlots to maintain a more consistent squirrel population than forest land where the animals do not have access to such supplies. Other field crops also contribute to the larder. Seeds and fruits of herbaceous plants, and

shrubs and vines in fencerows furnish the fox squirrel's salad course and add a few extra calories. These considerations suggest that fertile fields used for agriculture are also a part of the ideal habitat.

Housing

Most other conditions appear to be distinctly secondary to the food situation. However, in spite of the circumstantial nature of the evidence, it appears justifiable to conclude that plenty of hollow-tree dens also contribute to high squirrel numbers. A factor which so evidently aids them to survive the winter and protect their young through the period of helplessness certainly means more animals in the fall.

Overmature white oaks, beeches, and elms with numerous cavities are preferred home sites. Hence, an old stand of timber in which these trees have not been culled out provides most favorable housing conditions. And since fox squirrels have such a decided liking for black oak leaves as nesting material, it is difficult to visualize best-possible conditions for the species in a woodland not containing plenty of these trees.

The lay of the land

Size and shape of woodlands: Fundamental to nearly all conditions we have considered is the forest pattern. It is patent that the breaking up of continuous woodlands made most of southern Michigan habitable for fox squirrels. And all subsequent information implies strongly that the more woods edge there is, the better for this species. Small woodlots and woodlots of irregular shape have more borderline than large units or solid blocks. Hence it is obvious that the ideal range should be composed in part of timber stands a few acres in size and shaped for a maximum of edge between woods and open land.

Interspersion: The mixture of various woodland types also favors fox squirrels. It was noticeable at Swan Creek that these animals were more plentiful in the vicinity of a high bank along the riverbottom where three kinds of woodland occurred within a short distance. At the top of the escarpment scrub oak woods joined a strip of beech and red oak growing on the slope. At the bottom of the grade lay the riverbottom with its ash, soft maple, and elm.

Such combinations, of course, give that variety of tree growth referred to in the discussion of foods.

The intimate association of different kinds of woodland, and of trees with open land, quite evidently favors the fox squirrel, and the same general idea applies to many common animals. The principle is usually expressed by the term "interspersion." Its importance derives from the fact that few species in this region inhabit a single kind of cover, and practically all of the larger animals and birds require variety in their habitats. Leopold (68) has explained this necessity in familiar terms. "A city includes all of the environmental 'types' which human animals require for thrift and welfare. If, however, all the kitchens were situated within one quarter of a given city, all the bedrooms in another quarter, all the restaurants and dining-rooms in a third, and all the parks and golf courses in the last quarter, the human population which it would be capable of supporting would be considerably reduced." It is not difficult to understand that the more open fields, brush, marsh, and woodlands are broken up into units and mixed together, the more individual pheasants, rabbits, quail, and other animals have access to each cover type. And consequently, the more of these the land will support. In the development of favorable environments for midwestern game species, the intimate interspersion of differing types of vegetation is a major end.

Such principles as this must be considered broadly, for the squirrel job can not be handled alone. It must be made to fit into the greater plan of wildlife management which deals with all species of importance to man. In the case of the interspersion idea that is no liability, since from what is known now we could mix our fields, woodlots, and thickets almost *ad infinitum* and do only good for those species which are wanted in greatest numbers.

Lines of communication

Between the small woodlots of our "Grade A" squirrel range, boundaries should be well lined with trees. It has been shown that fox squirrels frequently move from one woods to another, and that they are sometimes caught by certain enemies when intercepted on the ground in the open. Trees along their travel lanes represent

◄ **Fig. 86. Oak-hickory woodland, growing on soil that is moist and fertile enough so that beech, red oak, basswood, and lowland trees are beginning to come in—that is probably the ideal woodland composition in most of southern Michigan.**

In leaf nests squirrels are exposed to storms, nest shooting by hunters, and possibly to some of their natural enemies.

comparative safety as well as a good source of food. Nothing is more evident in the excellent fox squirrel range of southwestern Michigan than the good lines of communication provided by bur oaks, hickories, and other trees in field boundaries and along roadsides.

Good Range and the Hunting Season

It is too much to expect that even an entirely reliable year-to-year food supply, many tree-hole dens, and other favorable habitat conditions would do away with fluctuations in squirrel numbers. The more favorable the range, the more plentiful animals become. And the greater the population density, the more vulnerable a species is to contagious ailments. Animals which have become sufficiently

numerous to reach the ultimate carrying capacity of their range compete among themselves for the necessities of life. Crowded conditions mean lowered vitality for individuals. And in such circumstances we can foretell an almost inevitable climax. Unless something equally effective supervenes, an epizoötic of disease or parasites can be expected to bring about reduction of the species. It is almost universally the case that animal populations do not endure an indefinite prosperity. When other factors fail, a species turns upon itself and destroys its own numbers.

What can be done about it? It is not certain; but the idea which seems most practicable and profitable is a swift, sure, and extensive population reduction in the hunting season. If best-possible habitat conditions were created, the fox squirrel would produce a maximum crop of litters, and maximum numbers of young would survive to fall. The entire population would bury a vast quantity of winter

Hence, an abundance of hollow-tree dens is one of the qualifications of a good habitat.

Fig. 87. Overmature and heart-rotted trees are likely to form good dens. This one is a white oak. In the ideal habitat such trees would be preserved.

provisions. Then the hunter would take a half or more of the squirrels. As winter advanced and the carrying capacity of the habitat declined, crowding would be avoided. The remaining squirrels would have an abundance of food and the best nesting sites in which to rear the next season's crop of young. Some such formula as this is what the wildlife manager is working toward.

Fig. 88. Irregularly shaped woodlots (above) have proportionally more "edge" than solid blocks (below) and are more favorable to fox squirrels. ▶

T. E. Daw

Fig. 89. The best habitats have good lines of communication between woodlands.

Summary of Chapter Ten

The most consistently productive fox squirrel range in southern Michigan probably conforms largely to the following specifications: It is mature oak-hickory woodland broken up into small units (possibly 5 to 20 acres), irregular in shape for maximum "edge," and connected with lines of trees or strips of woodland which serve as squirrel travel lanes. Mast trees stand in the open near the woods border. The woodlots are interspersed with upland and low-land thickets, and fertile fields used for growing corn and other agricultural crops. The oaks and hickories are varied with trees belonging to other woodland types, particularly such food producing species as walnut, elm, beech, and maple. Upland brush contains hazelnut.

Creation of ideal habitat conditions should produce maximum fox squirrel numbers. But dense populations of animals are particularly vulnerable to disease. Hence a large hunting season kill appears to be the best possibility for preventing the outbreak of epizoötics.

Part Three: Management

Chapter 11

THE TOOLS OF MANAGEMENT

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THE TOOLS OF MANAGEMENT

THERE ARE many tools available to the wildlife technician. Here we are concerned only with primary implements: the trees and shrubs which need to be planted in improving some woodlands, and cut for the betterment of others. Such things as nest boxes and winter feeders will be left for consideration in other chapters. Managing squirrels is largely a matter of managing trees. And forestry for wildlife is just as legitimate a human enterprise as forestry for sawlogs. It might also be added that it requires just as detailed a knowledge of the habits and characteristics of woody plants.

The possibilities in developing selected strains or hybrid forms of nut trees have been little explored. It is quite likely that the future will see numerous species of acorns and other nuts developed for commercial use, and some of these should grow in Michigan. If so, they may become useful in squirrel management. But for the present it is prudent to plan for the use of wild species and varieties naturally occurring here. Fortunately, we do not need one group of trees to provide food and another to furnish hollows. A list of the state's best food trees also includes those most valuable for dens.

Michigan's Important Mast Trees

In describing the trees most important to fox squirrels we will emphasize the conditions under which they grow. In general, it is best to plant each species in the kind of situation it occupies under natural conditions. But it is apparent from observations on trees planted by farmers in their dooryards and fence corners that there is a fairly wide range of tolerance to soil conditions when seedlings are set in the open to develop free from competition. It is competition which restricts the local distribution of most species. To use various trees and shrubs intelligently we must know where they will grow as a result of natural succession, and also what can be done with them when they are given a start free from interference.

The white oaks

In Michigan the trees belonging to this group are the white, swamp white, and bur oaks. A small amount of chinquapin oak is found in the southern counties, but it need not be considered here. These oaks are characterized by lobed, rather than pointed, leaves, gray scaly bark, and the fact that their fruit ripens in the year of flowering.

White oak: In primitive times mid-western forests were to a great extent characterized by the towering boles of 3-to-5 foot white oaks, many of them more than three hundred years old. In their impatience to clear the land, the pioneers felled the finest oak timber in the world and burned it where it lay. Today few of these stately trees remain, and the modern trend in forestry is for a quick turnover, with little attention given to a tree, however valuable, that takes two centuries to make a good log. In state-owned land where forest cropping is only one of many uses, white oak can well be encouraged for its value to wildlife and the sometime restoration of the forest grandeur so largely unappreciated by our forebears.

The white oak is among the most tolerant of trees. It is found from Maine to Florida, and Minnesota to Texas. It will grow on every kind of upland soil, but in moist situations it is less common than swamp white oak. In natural competition with other trees, it has been most successful on rolling clay or gravelly soils.

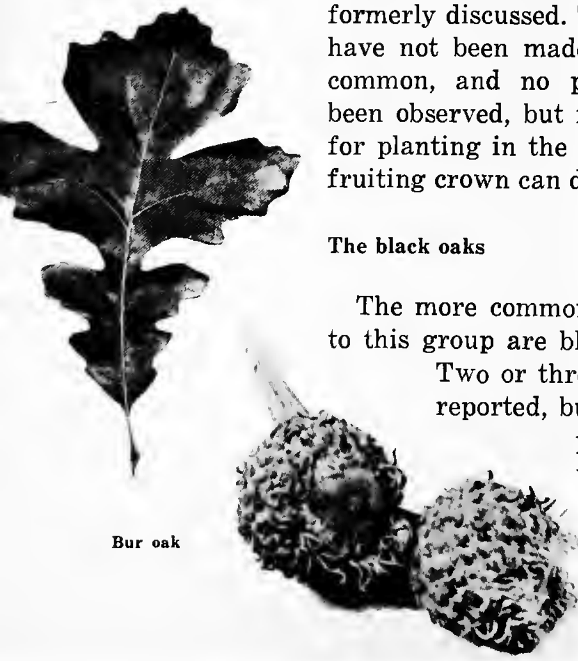
Acorns of white oak usually sprout the first fall, and the tree can be propagated either by planting the nuts, or better, by seedlings. In the summer growing period acorns are very succulent, and it is possible with the fingers to squeeze 8 to 10 drops of water from a large nut. Whether this is an important source of water to squirrels in dry uplands is not known. Unripe acorns are much less used than green hickory and walnuts.

Swamp white oak: Commercially, swamp white oak is not distinguished from the foregoing species. It is also commonly confused with bur oak, with which it is sometimes associated. In Michigan it is a common tree in lowlands. On sandy lakebeds swamp white and pin oak sometimes form solid stands to the exclusion of other species. River floodplains are a favorite habitat

Fig. 90. White oaks in a woodland mean good dens and large quantities of food.

White oak

Swamp white oak



Bur oak

of this tree and around the (former) prairie sloughs of southwestern Michigan it commonly associates with slippery elm, basswood, hackberry, sycamore, sugar and red maple.

Probably most things that have been said for white oak apply equally well to this species. In planting trees for management, swamp white oak should be substituted for white oak wherever the water table is near the ground surface.

Bur oak: The landscape of the oak openings and prairie edge was typified by the spreading crowns of bur oaks. A tree of this species still existing in Indiana is more than 7 feet in diameter, and the early botanist Michaux recorded one in Ohio which exceeded 14 feet at a man's height above the ground (26). Many prairie oaks are still to be seen in southwestern Michigan where they have been preserved in pastures and yards. A fine grove still exists in the city of Kalamazoo, which was built, in part, on a dry prairie.

Bur oak is well scattered over the southern part of the state. It usually occurs in moist situations, singly or in small groups, not forming an important constituent of woodlands as do the two species formerly discussed. The Michigan squirrel studies have not been made in areas where bur oak is common, and no particular relationships have been observed, but it should be an excellent tree for planting in the open where its large heavily-fruiting crown can develop free from competition.

The black oaks

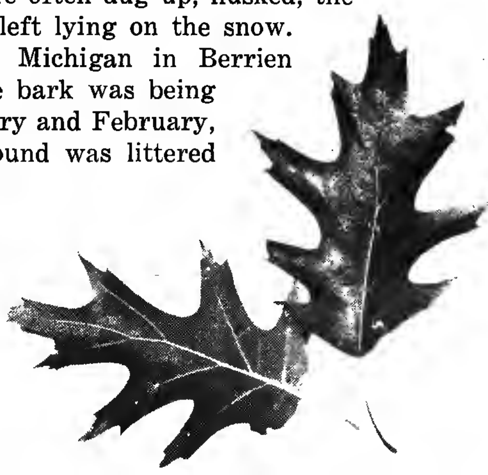
The more common Michigan species belonging to this group are black, jack, red, and pin oaks. Two or three other kinds have also been reported, but they are not important for present purposes. In general, these trees are more rapid

Black oak

growing than white oaks. Some should be well represented on state lands managed for squirrels, as the factors which govern their fruiting evidently are not the same as for white oaks, and where one fails the other may produce.

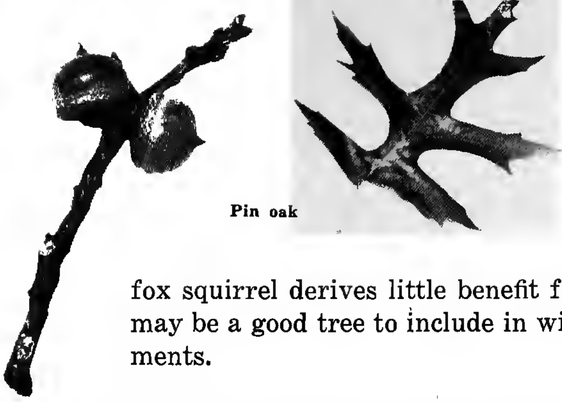
Black oak: This tree is one of the first pioneers on cleared pinelands, and it typifies the sand plains in parts of the north. It is also common throughout southern Michigan on all but the most fertile soils. In dry sterile situations it occasionally forms pure stands, which may subsequently be invaded by white oak. Black oak does not usually compete successfully in situations sufficiently fertile or moist to support red oak, but locally their habitats overlap. This species is usually associated with white, jack, and possibly scarlet oaks on the poorest soils, and with white oak and hickory in farmland woodlots. In most areas, black oak need not be planted and can best be managed by selective cutting. Its acorns are much used by squirrels, though more bitter than those of white oaks. They usually sprout in the spring, but evidence is good that some nuts buried by squirrels are still fresh and unsprouted after more than two years from the time of bearing. Black oak acorns are commonly used at all seasons, and their keeping qualities give them a place of importance in squirrel management areas.

Red oak: Observations thus far indicate that red oak is the least valuable of the common nut-bearing trees from the standpoint of squirrel management. The acorn is large, but very bitter, and it is little used as food by fox squirrels. In places where this tree is common, the nuts are often dug up, husked, the cotyledons nibbled a little, and left lying on the snow. In the dune area along Lake Michigan in Berrien County, hard maple bark was being much used in January and February, 1938, when the ground was littered with red oak acorns. Many had been gnawed or husked,



Red oak

Fig. 91. In moist woodlands red oak is a common species. Its fruit is bitter, and although squirrels open many acorns, the meats are usually left uneaten.

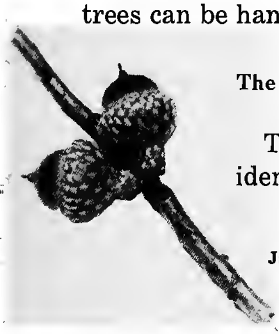


Pin oak

but only small amounts of the kernels were eaten. Acorns thus opened are made available to birds, and even if the fox squirrel derives little benefit from such food, the red oak may be a good tree to include in wildlife management developments.

Pin oak: This tree is most commonly found on poorly-drained mineral soils where it is often associated with swamp white oak and other lowland trees. In this state it is not a common river-bottom form, being more frequent in sand or clay areas where there has been little deposition of organic material. In such situations it probably should be encouraged as a mast-producing tree. The exact extent to which its acorns are used by the fox squirrel is not known. It is a desirable species from the standpoint of appearance, developing a symmetrical pyramidal crown when growing in the open. Pin oaks are small, rapid-growing trees which do not form the large hollow trunks most likely to contain good dens; but from what is known now, they should be a good source of mast.

Jack and scarlet oak: These two trees are commonly confused with black and pin oak. Their distribution has not been well worked out in Michigan. I have personally found jack oak from the southern counties to the Straits in the central portion of the state, but it appears to be absent from the Allegan County scrub oaks. Westveld (106) stated that jack oak is common on the pine plains, but that along the west side of the state it is replaced by black oak. In many areas, as at the Rose Lake experiment station, both species occur. Scarlet oak probably has been confused with jack oak in some reports. It does not appear to be common in Michigan, although it is said to occur in the pine plains. I have not found it growing in the wild. From the management standpoint these trees can be handled without discrimination from black oak.



The hickories

These are trees which even an expert cannot always identify. The most common species probably is the

Jack oak

Fig. 92. The jack oak is an important Michigan mast tree. It is often mistaken for black oak.

small-fruited hickory, which occurs in a number of varieties. The shagbark and bitternut hickories are also widely distributed in the southern half of the lower peninsula. The kingnut, or big shagbark, occurs sparingly in the southern counties, and the pignut and mockernut have also been reported for this area. Hickories are highly important to squirrel populations, and they will be much used in improving habitats for these animals. In general they are difficult to transplant, and hence are most successfully propagated by planting the nuts themselves. These trees grow rapidly and bear well when not crowded.

Small-fruited hickory: Formerly this species was not separated from the pignut, but it is now considered to be a distinct species (26). It occurs in a variety of forms in the same area and offers confusing problems in identification. The nuts are variable in size and shape, thin-shelled, and sweet. They are squirrel food of the highest quality and are used during the entire year.

Scarlet oak

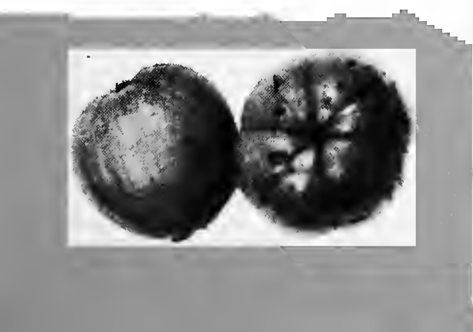
Small-fruited hickory

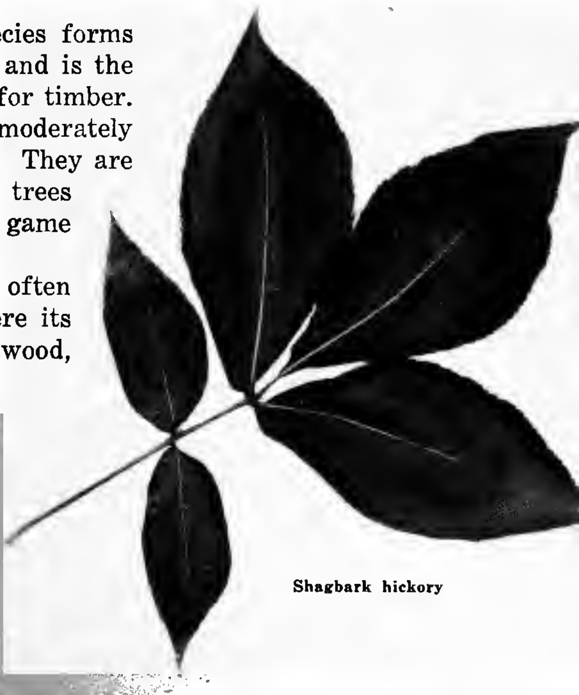
This tree is probably the most common of the woodlot hickories in southern Michigan. It favors well-drained slopes of moraines and till plains where its most common associates are white and black oak. It sprouts readily from the stump and quickly comes back on cutover woodlands. A characteristic of this tree observed at Rose Lake may make it of great value to squirrels in winters of deep snow. In 1942 the exceptionally early frost of September 29 evidently set the husks of nuts on some small-fruited hickories before they had time to dehisce properly. The result was that nuts were not dropped, and many trees in the vicinity held an abundance of fruit, far above the deep snow of January and February. Squirrels made good use of this food. The same observation has occasionally been made in other winters.

This tree should be suitable for planting on nearly any well-drained soil, but it can best be replaced by other hickories on low ground.

Shagbark hickory: This species forms tall trees with straight trunks and is the most valuable of our hickories for timber. The nuts have a thick husk, moderately thin shells, and a sweet kernel. They are ideal squirrel food, and the trees should be much encouraged on game areas.

Shagbark hickory is most often found on low rich ground where its associates are elm, ash, basswood,





Shagbark hickory

Fig. 93. Shagbark hickory produces high-quality squirrel food and marketable timber as well.

Bitternut hickory

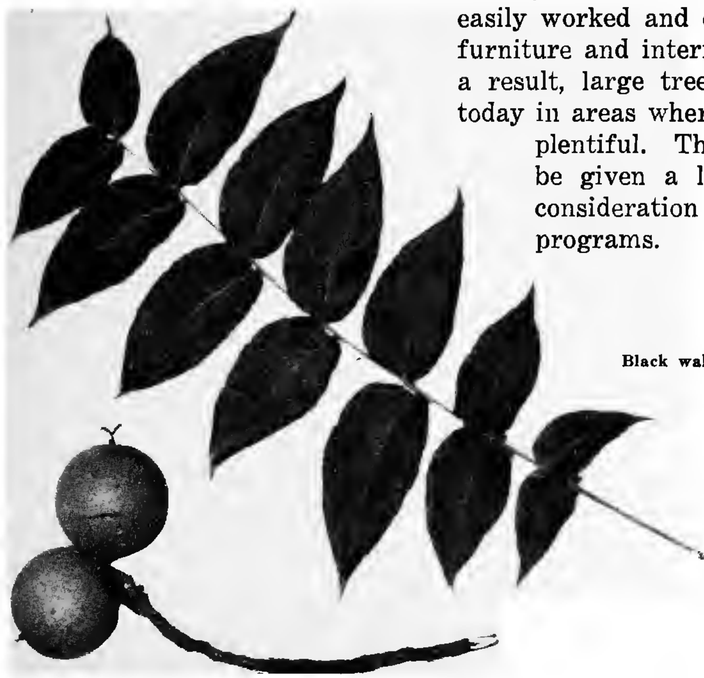
sycamore, swamp white oak, and hackberry. It is also commonly found in beech-hard maple woodlands. These trees are suited to use in bottomlands, moist areas, and good croplands.

Kingnut: The bigleaf, or big shagbark hickory, as this species is also commonly known, is similar in appearance to the former, but the nuts are very large and thick-shelled. It is found sparingly in bottomlands in southern counties and tolerates wetter situations than the shagbark. It should be excellent for use along stream margins and in low ground.

Bitternut: The bitternut hickory is well distributed throughout the southern portion of the state. It is a tolerant tree, being found on stream borders and moist lowlands as well as in the uplands. Whether or not this species is extensively used by squirrels is not known. Further work is necessary to determine its possible value in management plantings.

The walnuts

The walnuts are trees of fertile soil and well-watered situations. Black walnut was one of the first species to be cut from southern Michigan woodlands, the wood being easily worked and of good color for furniture and interior finishing. As a result, large trees are infrequent today in areas where once they were plentiful. The walnuts should be given a large measure of consideration in state planting programs.



Black walnut

Fig. 94. Formerly the black walnut was an important constituent of Michigan's southern woodlands. It is a species to be restored both for timber and squirrel management.

Black walnut: In the competition of the primitive forest the walnut evidently grew as individual trees or small groups where local conditions were right. It favored sunlit slopes bordering river floodplains and fertile hillsides in beech-maple-basswood associations. Although it was originally found only on better soils, experience has shown that this tree will grow on nearly any well-drained situation if it is exposed to sunlight. In the Allegan sand plains the early farmers planted numerous walnuts in their yards and fencerows. These trees have thrived and bear excellent crops of nuts on what is perhaps the poorest soil in the southern portion of the state.

Hardly a better species could be found for developing state lands. Nut gathering parties contribute to the public use of such areas, and the squirrels, which start the harvest in mid-summer, will see that nothing goes to waste. In the future, timber values should help to defray the cost of development.

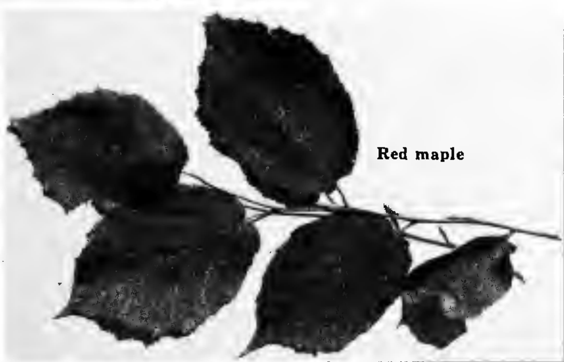
Butternut: The white walnut, or butternut, is not an abundant tree in Michigan. It is found in sandy portions of river floodplains, ravines, and gravelly seepage areas around lowlands. Large trees are seldom found, and those in the woodland probably bear little fruit. Deam (26) states that it is much more thrifty and fruits heavily when planted in the open. The possibilities of the butternut need further study, but it should be given a trial in the development of squirrel management areas. On porous soils around open stream banks it should prove to be a valuable tree in augmenting the lowland mast supply.

Beech

In relatively pure stands, or in association with hard maple, basswood, white oak, slippery elm, etc., the beech is a typical tree of heavier soils and well-watered situations. When these trees fruit heavily, they are an important source of squirrel food, but the meager information now at hand indicates that the species is unreliable in this respect. Charles C. Deam informs me that the beeches of northern Indiana have not borne an abundant mast crop for fifteen years. In southern Michigan I have not found a fully-fruited tree during the past seven years. Curiously enough, reports indicate that in northern Michigan good beechnut crops are relatively frequent.

The beech is somewhat difficult to transplant but probably should be included in moderate numbers in management developments. It is a tree of great beauty, clean-limbed, resistant to disease, and an excellent den tree.

American hazelnut



Red maple

Beech

Fig. 95. In Michigan the beech-mast crop often fails, but the tree is a source of squirrel food in some of the state's best farmland.

Red Maple

Hazelnut

The only important mast-producing shrub in Michigan is American hazelnut. It is among the most tolerant of our shrubs, and is one of the first woody plants to spread onto the prairies. It is plentiful in sandy and heavier soils alike, spreads rapidly, and is easily propagated from both seeds and cuttings. In the open it bears heavy crops of nuts which are esteemed by humans and rodents alike. Observations indicate that when the nuts are shed a large percentage of them are carried away by mice, but fox squirrels use them also. In some seasons the nuts are persistent within the involucre and thus remain available all winter.

The state's management areas will be developed for rabbits, squirrels and other wildlife, and hazel will produce mast and ground cover simultaneously. There is not another native shrub which offers the advantages of the hazel from this standpoint. It should be emphasized wherever open areas are to be planted for the encouragement of small game.

Other species

As was pointed out previously, maples and elms are important food trees for squirrels, furnishing buds in winter and seeds in late spring and late summer. These trees are so common in the state, wherever conditions are suitable, that there will be little need for planting them in their natural habitats. There may be occasion to plant them in open uplands to provide variety, good dens, and seasonal foods where needed. They are tolerant trees and will grow nearly anywhere.

The chestnut was formerly plentiful in some areas of southeastern Michigan, and this would be an important mast tree were it not for the "blight" which has nearly exterminated it in large areas of its range. It is probable that blight-resistant varieties, such as the Chinese or hairy chestnut, will be of greater use in game management than the native species.

Fig. 96. The hard maples fruit in summer and help to fatten squirrels before the coming of winter.

Summary of Chapter Eleven

The most important tools of the squirrel technologist are the mast trees which in part compose southern Michigan squirrel woodlands. Chief among these are white and black oaks, and small-fruited and shagbark hickories. Several other species, such as jack, pin, swamp white, and bur oaks, black walnut, butternut, big shagbark hickory, elm, hard and soft maples, and beech, will be useful in plantings to provide additional sources of squirrel food where it is needed. Hazelnut should also be used for this purpose, since it is an easily propagated shrub which fruits plentifully, spreads rapidly, and forms good ground cover for other kinds of game.

Chapter 12

FOX SQUIRRELS ON THE FARM

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AGRICULTURAL LAND USE

THE PIONEERS distinguished roughly between "pine land," by which they meant light soils most often occupied by pine forest, and "hardwood land," the heavier, more fertile soils which usually supported broad-leaved trees. To simplify the formulation of broad management specifications, we can use a somewhat similar classification here. Areas too light or hilly for agriculture are now commonly classed as submarginal to distinguish them from land that can profitably be farmed. Submarginal areas offer a unique wildlife management problem, which will be discussed in the next chapter. For the present we are concerned with the possibilities of raising a larger crop of fox squirrels on the average southern Michigan farm.

What Wildlife Means to the Farmer

Most farmers enjoy having wild animals and birds on their land in reasonable numbers. They do not welcome concentrations so large that crops are destroyed. Nor do they take readily to expensive, cumbersome, poorly-considered management techniques. The farmer's first job is to earn his living; and in spite of what an excess of enthusiasm might lead us to believe, the market value of the bird in the bush is very low indeed. Hunting rights are a merchantable commodity under some exceptional conditions. But on the average farm, game (and other wildlife) must pay its way through the enjoyment the landowner derives from seeing and hunting it personally and from dispensing favors to his friends.

Thus, since the tangible reward is low in monetary value, the methods used for attaining it must be low in cost. About all the average farmer can be expected to invest to increase his shootable surplus of game is a reasonable consideration, the avoidance of unnecessary destruction, and perhaps a little time. Anything he does beyond that will in most cases need to have other values attached. It is the wildlife technician's job to tell the landowner what can be accomplished within the limits of what he can afford to do.

Management Opportunities

Fox squirrels are primarily dependent upon woodlots. In highly productive farmland it is economically sound to reduce woodlots to a minimum. However, there are few areas where even the best land is not interspersed with streambank slopes, ridges, or swampy areas which can produce trees but little else. And farmers who have all the cleared land they can work may prefer to retain existing woodlands on potential cropland. It was shown in the case of Clinton County (p. 45) that a good agricultural region can also be favorable to fox squirrels. Thus the 6,800,000 acres of first-class agricultural land in the southern half of the lower peninsula represents fairly good squirrel range, even though, owing to the intensity with which it is farmed, opportunities for applying measures to increase such a low-yield crop as game are definitely restricted.

Farmland game management in southern Michigan can best be practiced on second and third class soils, of which there are more than 7,000,000 acres. On farms of this kind agriculture is not so intensive, a considerable acreage is profitably utilized in (usually oak-hickory) woodlot, and odd corners can be devoted to game because they will not produce anything else. In addition, the hilly nature of much of this land necessitates methods of agriculture especially favorable to most wildlife species. Thus, in present squirrel management plans, techniques will be adapted to the rolling, morainic areas of the southern part of the state, and they can be applied elsewhere to the extent that local conditions warrant.

The Farm Pattern

On hilly second and third class land, a considerable change in the farm pattern will eventually be brought about. As a result of work by the Soil Conservation Service and various agricultural agencies, a start has been made in this direction.

Agriculture and straight lines

In the original land surveys, townships and farms were laid out regardless of natural surface features, and property lines usually ran parallel and perpendicular to one another. Continuing this

Fig. 97. On a properly planned farm cultivated crops are confined to the more level land, and steep slopes are occupied by woodlots which produce timber and prevent erosion.

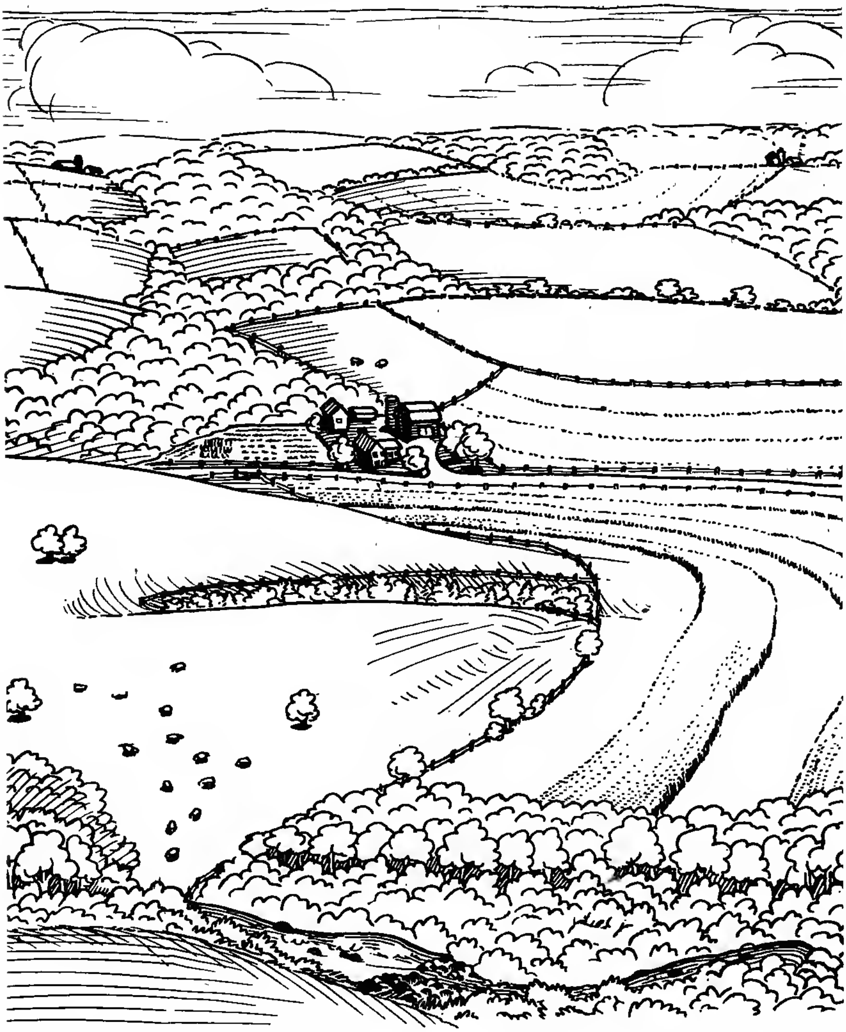
process, farmers laid out rectangular fields and largely ignored ravines, hillsides, and watercourses. A given 10-acre plot might be left in woodlot, even though most of it was level and tillable. Another field would be entirely cleared and cropped despite the fact that a portion of it consisted of steep slopes and "knobs." The result of such a procedure in laying out and cultivating farms was the widespread erosion which can be seen from nearly any country road in hilly portions of the state. The washing of a few inches to several feet of topsoil into lowlands has left a perennial "crop" of rocks on the hills and piled up the best part of the land in depressions. There, by a continuation of washing, it is covered with further deposits of mineral soil. The improved methods of land use which are now being demonstrated on sample areas in Soil Conservation Districts are calculated to reduce erosion and build up fertility.

On page 262 is shown a theoretical farm laid out according to "square" farming methods. The fields are for the most part in 10- and 20-acre rectangular units, and cultivation has been parallel

THIS FARM WAS COMPLETELY "RUN DOWN" DUE TO IMPROPER PLANNING AND LAND USE

Many of the farmers who cleared the original forest did not plan their farms with a view to preserving the natural fertility and productivity of the soil. Fields were laid out with little reference to topography. Steep slopes were cleared and woodlots left on level ground—with serious gullying and sheet erosion the result. Newer methods of farming are being designed to prevent the land from becoming "run down" in one generation.

A SOUND BASIC PLAN AND GOOD MANAGEMENT MEAN SUSTAINED PROFITS AND MORE WILDLIFE



This is how the farm on the opposite page might appear after 20 years of good management. It has been replanned with reference to the topography rather than section lines. The more level land is devoted to cultivated crops grown in alternating contoured strips of grain and hay to minimize erosion. The hills have been devoted to long-rotation pasture, and former gullies have been planted to soil-binding shrubs and fenced against grazing. Woodlots are located on the steepest grades to render such land productive and to protect watersheds from gullying. By a dam of field stones the farmer has raised the water table and created a stock pond.

with field borders rather than surface contours. Furrows up and down slopes hastened the washing of topsoil, and gullies have resulted. Areas which might have been used intensively, such as the level woodlot, have yielded only a portion of what could have been obtained from them; and slopes which should have received only extensive use have deteriorated into rocky waste under frequent cropping. It is doubtful whether 80 or 100 acres in a farm like this are sufficient to support a family. This may not have been so thirty years ago because of higher prices and the better condition of the soil at that time.

Contour farming

The sketch on the opposing page shows how the land pattern in this hypothetical area might appear after more progressive farming methods have been instituted. The farm is now 160 acres or more in extent, and the field pattern has been revised on a basis of topography rather than section lines. The woodlot has been cleared and included with the level, short-rotation cropland. The abrupt slopes of the stream bank are being allowed to grow up to brush

Fig. 98. Slopes such as this can yield wood products indefinitely, but they are quickly depleted by cultivation or overgrazing.

and trees and will be a future woodlot. At a strategic point a field stone dam has backed up a small pond which will retain water the year around for stock, provide fish and muskrats, and help to maintain a high water table under the adjacent fields. The more gently sloping areas have been consolidated into grazing land, which will be broken for reseeding to forage crops only as often as necessary to maintain a productive pasture. Cropland of this farm has, in convenient places, been divided into strips which will be cultivated on the contours. Thus all implement furrows extend across the grade and give less opportunity for washing to start. In crop rotations strips of hay are alternated with grain so that only a portion of any hillside at any given time will be unprotected from erosion.

It is not expected that such changes as this will be brought about suddenly by a large investment of cash. Large-scale adjustments take time. They will develop gradually as better methods are made available to the individual and government encouragement directs the trend of changes along the lines of a practicable plan. But it is fairly certain that the movement will grow, because unless constructive measures are put into effect, many badly depleted areas will go out of agricultural production. Several hundred years' experience in England and Europe show that hilly land similar to much of that in Michigan's till plains and moraines can be permanently productive in agriculture if it is properly used.

Modern methods and the fox squirrel

This trend in agriculture has been stressed because it is fundamental to the entire game management program in southern Michigan. Much of the work at the Rose Lake station is proceeding along these lines. It should be quite evident that a modernized farm is a better fox squirrel habitat than one operated under the old methods.

The principal reason for this is the increase in edge. Contoured pastures and woodlots are irregular in shape, and strip-cropped fields present a large extent of borderline between different kinds of cover. On many areas woodlot sites will vary from the highest uplands down to the streambottoms. These will support that variety of tree growth which gives the fox squirrel a more dependable food supply (p. 226). In croplands small gullies and waterways are in sod and brushy escape cover. These further break up

the pattern, furnish various fruits and seeds, and provide small "waste" areas where nut trees can grow.

From the standpoint of squirrel management, the most promising condition on a modernized farm is the size and shape of woodlots. In principle, areas not suitable for more valuable crops should be devoted to trees. This will locate many woodlots on the sides of narrow slopes (fig. 97) and in small units. Such woodlands have extensive borderlines, and much larger mast crops can be expected than if they were solidly blocked. Such tree growth also forms excellent communication lines. From what has been learned at Rose Lake and elsewhere, hilly land managed according to the best soil conservation and agricultural practices approaches closely the most up-to-date ideas of what a good farm wildlife habitat should be. And the idea applies particularly to the fox squirrel.

WOODLOT MANAGEMENT

The silvicultural practices used by a farmer certainly have a direct influence on the animals inhabiting his timber stands. Hence it will be profitable to consider how a woodlot should be managed for the greatest cash return, and whether this can be reconciled to a reasonable extent with habitat requirements of the fox squirrel.

Woodlots for Profit

The returns to be expected from a farm woods are principally in the form of sawlogs and posts to be marketed, and fuel wood usually utilized by the owner himself. The possibilities for improving farm income through woodlot management evidently are being neglected. It has been estimated (14) that, of 138 million acres of farmland timber with potential commercial value in the United States, only 30 percent is getting any sort of intelligent use, and only one percent is receiving really good intensive management. Numerous bulletins have been written on the care and harvesting of woodlot products (21, 23, 27, 50, 81, 96, 107), and a farmer can always get information on the subject by consulting the Department of Agriculture or his state agricultural experiment station. In outlining the most desirable silvicultural methods, we will accept what appears to be the consensus among authorities on the subject in this region.

Fig. 99. Trees in a dense stand grow tall with few limbs and make good sawlogs. Young trees quickly fill in gaps left by selective cutting.

Conditions in a productive woods

A properly managed woods should be permanently productive, and this depends upon maintaining certain conditions in the stand. It should be composed of trees of all ages, from seedlings to mature timber ready to cut and market. Sawlog trees should be in close stands, which causes them to grow tall and straight, with clean boles and few branches. Such a stand should, of course, be a mixture primarily of those species whose market value is high. The soil of a healthy woodlot is loose, moist, and crumbly. It is

Fig. 100. In a productive woodlot the closed canopy and heavy undergrowth allow little sunlight to strike the ground. Air currents are reduced, and the woods floor is kept moist, porous, and free from sod.

protected from drying out by a thick layer of leaf mold and an undergrowth of shrubs. Water quickly soaks into the porous ground, and evaporation is slow. Little sunlight strikes the woods floor because of the closed canopy and shrubby understory. Under these conditions grass cannot grow, and seedlings sprouting in the rich duff have little competition from herbaceous plants.

Cutting

By means of cuttings, timber is marketed and the stand improved for future profits. Usually merchantable products are harvested every winter or every few winters, according to convenience. Most farmers do the cutting themselves in the slack season, thus marketing both wood and labor, although trees can also be sold on the stump. Trees selected for cutting usually are sufficiently well scattered to leave only small openings. Saplings quickly grow up to close the canopy again.

In most woodlots a considerable portion of the cutting should be for stand improvement and firewood. The so-called "weed" trees vary according to locality, but in general, ironwood (or blue beech), hop-hornbeam (or ironwood), hawthorn, sassafras, and dogwood have no merchantable value and are utilized as firewood, thus giving more space to marketable trees. Other species not ordinarily desirable for timber are pin oak, scarlet oak, red maple, box elder, and beech.

Thinning is important for increasing the growth of desirable trees. Where young trees are growing in a dense stand, it is often advisable to cut out the less thrifty to permit the remainder to develop larger tops and grow more rapidly. The stand is left sufficiently dense to insure straight, clear logs. Trees which start in small clearings sometimes overtop more valuable competitors and develop broad bushy crowns. These "wolf trees" are culled out for firewood along with misshapen, overmature, and hollow individuals of all kinds.

The most desirable timber trees in this region are basswood, walnut, white ash, red oak, tulip poplar, white oak, and sugar maple. The last two are of high value, but they grow slowly and ordinarily are subordinated to more rapid growing kinds. Under some conditions, markets develop for elm, hickory, black cherry, black oak, cottonwood, beech, and others. Some of these species may bring good prices in the case of choice logs for specialized

uses, and cheaper grades of lumber commonly go into rough construction on the farm or are sold for boxwood and similar uses.

In harvesting wood products clear-cutting should ordinarily be avoided. On land adapted to permanent woodland the greatest return can usually be obtained by cropping individual trees as they reach their most marketable condition rather than by taking all at once. Clean cutting or over-cutting dries out the woods floor, and permits the entry of brambles and other plants which compete with the reproduction of valuable trees.

Grazing

Foresters frequently deprecate the practice of grazing woodlots. It is the most common kind of mismanagement. The 1935 census report gave a total of 2,883,217 acres of pastured woods for Michigan farms and only 932,907 acres of unpastured woods. From this cause alone, about three-quarters of our woodlots are being used in a manner that represents a loss to their owners.

A pastured woods is neither a good timber stand nor a good pasture. If heavily grazed, it eventually ceases to be a woods, since trees have no means of reproducing themselves. Not only are seedlings and shrubs eaten, but the soil becomes packed, the ground dries out, leaves blow away, sod forms, and conditions become such that tree seeds can no longer sprout. Soon the farmer has only a badly shaded, and hence poor, pasture. If the woodlot has been located where it usually should be—on the steepest grades of the farm—grazing may induce erosion and thus defeat one of the most important purposes in having trees on such sites.

It has been shown that the yield and nutritive value of grass in a wooded pasture is far below what it would be if the trees were

THREE-QUARTERS OF MICHIGAN FARM WOODLANDS ARE GRAZED.

Fig. 101. Grazing plus cutting means the end of a woodlot—on the type of land where trees are the best crop. Woodland-protected slopes do not erode appreciably and provide the farmer with sawlogs and firewood.

cut and the area managed for grazing alone (105). As a general statement, land on southern Michigan farms which is too steep for cultivated crops should be either in long rotation pasture or woodland. But it should not be used for both. Grazed or burned woodlands may be favorable to the fox squirrel as long as they last. But as a general rule they do not represent the best value for the farmer, and that is the point we are considering here.

Burning

The results of failing to protect a woods from fire are essentially similar to those of grazing. Burning destroys the leaf mat and humus, and shrubby growth is killed. This opens up the stand to

the drying action of winds and induces the formation of sod. The large trees themselves may be damaged, permitting the invasion of insects, fungi, and rot organisms. Woodlots most often catch fire accidentally when fencerows, pastures, and marshes are being burned in the spring. This practice is one to be avoided, since it helps to induce erosion and destroys nestling birds and cottontails. Burning is not recommended by agriculturists. In this region it has no known value on the average farm for improving pastures or controlling insects and weeds. If no burning at all is done, the woodlot is not likely to burn. The use of controlled burning for maintaining openings in public game areas is a different matter (p. 289).

Woodlots as Fox Squirrel Habitat

Having evaluated the most common woodlot management practices in terms of a farmer's income, we will now consider them for their effects on fox squirrel populations.

Fig. 102. The burning of fencerows, marshes, and pastures has no known value to farm operation and is destructive of property and wildlife. Such fires sometimes get into woodlots and destroy the natural leaf mulch and tree reproduction.

Fig. 103. Grazed woodlots may be good fox squirrel habitats. But they are neither good timber stands nor good pastures for the farmer. Since they can not reproduce, they will eventually cease to be woodlands.

Squirrels in grazed woodlots

As far as habitability for fox squirrels is concerned, grazed woodlots seem to be as good or better than ungrazed ones. The original home of the species in open oak groves bordering the prairie probably was not dissimilar to a pastured woodlot. In fact herds of bison or bands of browsing elk may have been a common sight to the fox squirrel in pre-revolution times.

Table 10 gives summer populations of fox squirrels and smaller squirrels (chipmunks, flying squirrels, red squirrels) as indicated by box trapping in seven woodlots at the Rose Lake station in 1940. It is evident from this tabulation that fox squirrels were more numerous in the grazed units and that smaller squirrels were most plentiful in unpastured samples. Red squirrels, chipmunks, and similar rodents compete with fox squirrels for food, and probably to some extent for dens. This may well be the main reason for the

difference. The woodmouse and prairie deermouse store away caches of nuts and other squirrel foods, and because of their numbers these animals probably are important food competitors. The woodmouse is very likely most plentiful in an unpastured woods, although this has not been demonstrated.[25]

TABLE 10

Fox Squirrel and Small Squirrel Populations in Grazed and Ungrazed Woodlots

Rose Lake Wildlife Experiment Station — 1940

		Grazed[26]
Woodlot number	*Fox squirrels per acre*	*Competing Sciuridae per acre*
2	1.6	1.6
3	1.7	.8
4	2.6	1.5
Average	2	1.3
		Ungrazed[26]
Woodlot number	*Fox squirrels per acre*	*Competing Sciuridae per acre*
1	1.9	1.6
5	1.2	3.4
6	.7	2.8
7	.9	1.9
Average	1.2	2.4

The figures obtained at Rose Lake indicate that open, grazed woodlands tend to support more fox squirrels than stands with the dense understory which bespeak a "healthy" woods for the farmer. But the wildlife manager should not recommend a practice which is not good economics and which would eventually destroy the woods itself. Game and timber are alike in that it is more impor-

[25]The species mentioned here are: Southern red squirrel *Tamiasciurus hudsonicus loquax* Bangs; Lyster chipmunk, *Tamias striatus lystsri* (Richardson); Eastern flying squirrel, *Glaucomys v. volans* (Linné); Woodmouse (Northern white-footed mouse), *Peromyscus leucopus noveboracensis* (Fischer); Prairie deermouse, *Peromyscus maniculatus bairdii* (Hoy and Kennicott).

[26]The terms grazed and ungrazed are here used advisedly. At one time or another probably all of these woodlots were grazed. In some the understory has sufficiently recovered to present an ungrazed appearance, and these are considered to be unpastured units in this comparison.

tant to maintain the farm grove in a permanently productive condition, even though it might be possible to realize a larger immediate profit by methods which would lead to its destruction.

Mast, timber, and dens

The best squirrel food trees are not identical with species which the farmer would select for best timber production. For greatest mast supplies the oaks, hickories, walnut, and beech would be the trees to favor. A few elms and maples would also help. The oaks and walnut are good sawlog as well as food trees, although red oak, a rapid growing species, is poorest in the quality of its mast. Hickory is secondary for timber. Beech is least trustworthy as a mast producer and a low quality timber tree, although it makes good firewood. Ash and basswood are among the best sawlog species, but they are distinctly secondary sources of squirrel food.

A forester who considered wood products alone would inevitably cull all heart-rotted, stag-headed, hollow, misshapen, overmature, or diseased trees in the woodlot. The wildlife technician would prefer to allow some of these to remain as dens. Such inferior trees occupy space which might be devoted to more valuable specimens, and they are sometimes considered points of dissemination for insect pests and plant

Fig. 104. The wildlife manager would urge a farmer to retain some of the overmature rotted trees and stubs in his woodlot. Limited numbers of these should not interfere to an important degree with good forestry.

diseases. However, these things are of relatively minor importance, and few foresters object to the preservation of a reasonable number of den trees (one or two to the acre?) when the wildlife value is considered.

Silviculturists also do not reject the suggestion of retaining a mixture of hickory and other low-quality timber species in the woodlot. A mixed stand of trees is less susceptible to disease and pests than one composed of few kinds. In addition, under some circumstances shade-tolerant species such as beech and hard maple help to keep the stand closed and through competition cause other trees to grow tall and straight.

What the Farmer Can Do

It is evident that the most valuable measures which a farmer can employ to favor squirrels are things which he will do anyway purely from an economic motive. He will devote land not capable of more intensive use to woodlots; he will harvest wood products selectively; and he will protect his timber stands from fire and grazing. Some of the possibilities for disagreement between "pure forestry" and fox squirrel management have been pointed out, but these points of variance seem to be fairly easily reconciled. Even a farmer who is very conscientious about his silvicultural practices can at the same time carry out constructive measures to benefit fox squirrels by a judicious use of the woods edge, fencerows, and odd corners.

The edge of the woodlot

The large amount of edge around small, irregularly-shaped woodlands has received emphasis as a condition highly favorable to fox squirrels. From the timber standpoint the woods margin is not of great value. Most borderline trees do not make good sawlogs, and about all the farmer can hope to realize from them is firewood. Good silviculture would be more easily practiced if an owner had a forty in solid woodland rather than many small units. But a farmer's primary interest on Michigan's second and third class land is to "tie down" the soil on problem areas and to get whatever

Fig. 105. If every farmer does nothing more than manage his woodlands for a sustained yield of marketable products, there will be good squirrel hunting for future generations. ▶

he can from it while restricting intensive agriculture to his most level fields. Whatever conditions this imposes must be accepted.

The low value of trees on woods margins presents a possibility to improve conditions for squirrels. Here a farmer can afford to encourage beech, hickory, and other good mast species. They will furnish fuel when he wishes to cut them, and they can function as well as other kinds in keeping the stand closed. Within the woodlot only small seed crops are produced anyway, and hence sunlit borders are by far the best place for food-bearing trees. Hollow and decadent specimens can also be left on the edge in numbers, with minimum infringement of the living space of valuable timber. In actual practice, however, an interested farmer probably will leave a good den tree wherever it occurs.

Fencerows, etc.

Aside from preserving his woodlots, the most beneficial thing a landowner can do for squirrels is to allow mast trees to grow in fencerows, pastures (cows need shade), ditch banks, gullies, waterways, and unused corners. It is not expected that he would encourage such trees to the extent of shading valuable crops or interfering with machinery operation. But there are many places on an average farm where hickories or other mast trees can be preserved as they spring up without being a hindrance to profitable farming. Planting food trees is better yet, since it speeds the establishment of the most desirable species in the best locations. Farmers sometimes plant walnuts in their fencerows with evident good results. But in such a long-time program as this, it is practicable to depend upon the natural succession both to establish woodlots on the proper areas and to bring about a favorable distribution of open-growing food trees.

The encouragement of mast bearing trees is of chief importance, but the same proposition applies to shrubs and vines. Thickets of hazelnut are particularly worthy of preservation, and nearly all woody plants bear fruit useful to the fox squirrel or its food competitors. Brush cover also increases the safety of ground travel for this species and is a prime essential in rabbit management.

In chapter 14 are discussed several short-time management measures, such as winter feeding or nest boxes, which can be applied on the farm, but which are not recommended as practicable for the *average* landowner. They are special measures for people

who have a special interest. For all ordinary purposes a little foresight and planning are all that are required to create a favorable fox squirrel habitat in much of Michigan's southern farmland. The measures that have been described can cost at the most a little time and at the least a conscientious attention to self interest. If every farmer does nothing more than handle his timbered acres for a sustained yield of marketable products, there is little question that future generations will be shooting plenty of fox squirrels.

Summary of Chapter Twelve

The best opportunities for managing fox squirrels on farms are in second and third class agricultural land. In such territory "problem" areas susceptible to erosion can be devoted to growing trees or improvements for wildlife because they will not produce more valuable crops.

Modern trends in agricultural land use are particularly promising for creating favorable fox squirrel range. Contour farming and various soil conservation practices which it involves tend to increase the amount of edge between cover types and create small irregularly shaped woodlots. The extensive borderlines of such woodlands contain more large-crowned well-lighted trees than the comparatively shorter margins of large blocks, and for this reason produce correspondingly greater crops of squirrel food.

Farmers who so desire can aid squirrel production by retaining or planting mast trees in fencerows and odd corners of the farm.

Considering timber production alone, foresters would largely eliminate from woodlots trees of low market value such as hickory and beech. They would also cut out all defective specimens. Good squirrel management calls for the retention of mast-yielding species and a reasonable number of hollow den trees. Little will be lost by devoting the edge of woodlots to these, since marginal specimens seldom form good sawlogs and are chiefly used as firewood.

Chapter 13

FOX SQUIRRELS ON SUBMARGINAL LANDS

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SUBMARGINAL LAND USE

THERE ARE approximately 6,800,000 acres of first class agricultural land in the south half of the lower peninsula (103). In this same region there are about 7,050,000 acres of second and third class soils. The remainder, roughly 693,000 acres, is fourth class land too hilly or too infertile for profitable farming.

The position of fox squirrel management in the use of agricultural areas was examined in the last chapter. Now we are similarly concerned with submarginal lands. Game and other wildlife have a relative value dependent upon economic conditions in any given district. In regions of intensive farming this value is low. It increases wherever farm crop yields decline. It is highest where other types of production bring the lowest return. This is a matter of relative human interests, of course, for fertile soils yield more game than infertile ones. We simply can not afford to devote them to such production.

Land Planning

This sliding scale of values was not always so apparent as today. It has been accented by such social problems as the reversion of more than 5,000,000 acres of (principally northern) tax abandoned land to state ownership (90), and the resettlement of farm families from land too poor to support them. Nearly all of southern Michigan not in trees or under water has been broken with the plow. It is by trial and error, rather than foresight and planning, that various areas have come to be used for specialized purposes.

In the past 20 years there has been a growing appreciation that trial and error are the hard way—that mistakes can be avoided by efficient planning for the use of natural resources, including the soil. A national land-use planning program, operating through county and state committees, has been initiated by the U. S. Department of Agriculture. It brings to local people the technical aid they need in directing their land-use policies and practices along sound and profitable lines. The motivating idea is that the soil and its wealth are an estate to be handed from one generation to the next, upon which it is the duty of each to collect the interest and enrich by wise utilization, but which none may selfishly exploit by squandering the principal.

Economics of Submarginal Areas

The principal has already been spent in many cases. One can not drive far along the state's highways without seeing eroded hills which would be more productive had they been left in forest cover. Extensive tracts of light sand were cut-over, repeatedly fire-swept, and then confidently plowed up and homesteaded. In some such areas there are sand blows 20 to 40 acres in extent (fig. 106) where corn was planted twenty years ago. Submarginal soils do not ordinarily yield large crops of anything. To use them for agriculture depletes their low fertility in a few years and reduces their productivity for a long time to come.

Some of the fourth class land is in small units interspersed with agricultural soils. Much of it is also near urban centers. There is a growing appreciation of this type of situation as a place to live; and with improved transportation facilities, increasing numbers of city-employed people can be expected to establish homes in rural areas. Although individual holdings may be limited, many people are interested in developing the wildlife possibilities of their forty acres for its esthetic and hunting values. Such owners should be able to apply these squirrel management recommendations to any extent that they wish.

Many of the larger areas of submarginal land will come into state ownership. According to the present working concept, fourth class soils in southern Michigan are suited mainly to forests and recreational use. Game for hunting, of course, is classed with recreation. Few can afford to own large tracts of land just for hunting, pic-

Fig. 106. In 1921 this was a cornfield. It is now a part of the Allegan State Forest. The principle is gaining recognition that submarginal soils are best suited to the production of trees, game, and recreational facilities.

nicking and similar purposes. But the people as a whole (the state) can afford to own it for this just as they support swimming pools and theatres.

Eventually there may be half a million or more acres of state land in the south half of the lower peninsula. Through the Federal Aid in Wildlife Restoration program (17) a start has been made in the establishment of public game areas in this region. Fig. 107 shows the approximate distribution of larger tracts of fourth class land and the acquisition projects set up thus far. At the end of 1942 purchases out of the Pittman-Robertson fund (17) aggregated 32,055 acres. Areas in Allegan County and Jackson County were acquired by long term lease from the federal government (resettlement projects).

With the exception of certain experimental and refuge tracts, all public game areas are open to shooting and are being developed by the Game Division for increased hunting yields. It is not practicable to attempt a large production of pheasants on them, because investigations have shown that high populations of these birds in Michigan are attained only in fertile, highly-productive farming regions. Rabbits and fox squirrels provide most of the hunting on submarginal land, and habitat improvements for these species are being integrated into one program. Here we are interested in what squirrel management developments are practicable for application on a large scale where game is a primary rather than a secondary (as on farms) value.

FOX SQUIRREL MANAGEMENT IN GAME AREAS

Game, forest, and recreational land in southern Michigan consists, for the most part, of run-down or abandoned farms. Such areas are characterized by blocks of open fields (fig. 108) and, in some places relatively large tracts of woodland. Frequently there is lack of interspersion between types, and poor variety in tree species and ground cover. There are numerous old fences and tumbledown buildings. Where the land is level and sandy, as in Allegan and Tuscola Counties, wind erosion has left blowouts in need of soil-binding vegetation (fig. 109). Where the land is hilly, as in most state projects, extensive gullies in overgrazed and overcultivated slopes are much in evidence. Soil stabilization is a problem in nearly all submarginal tracts.

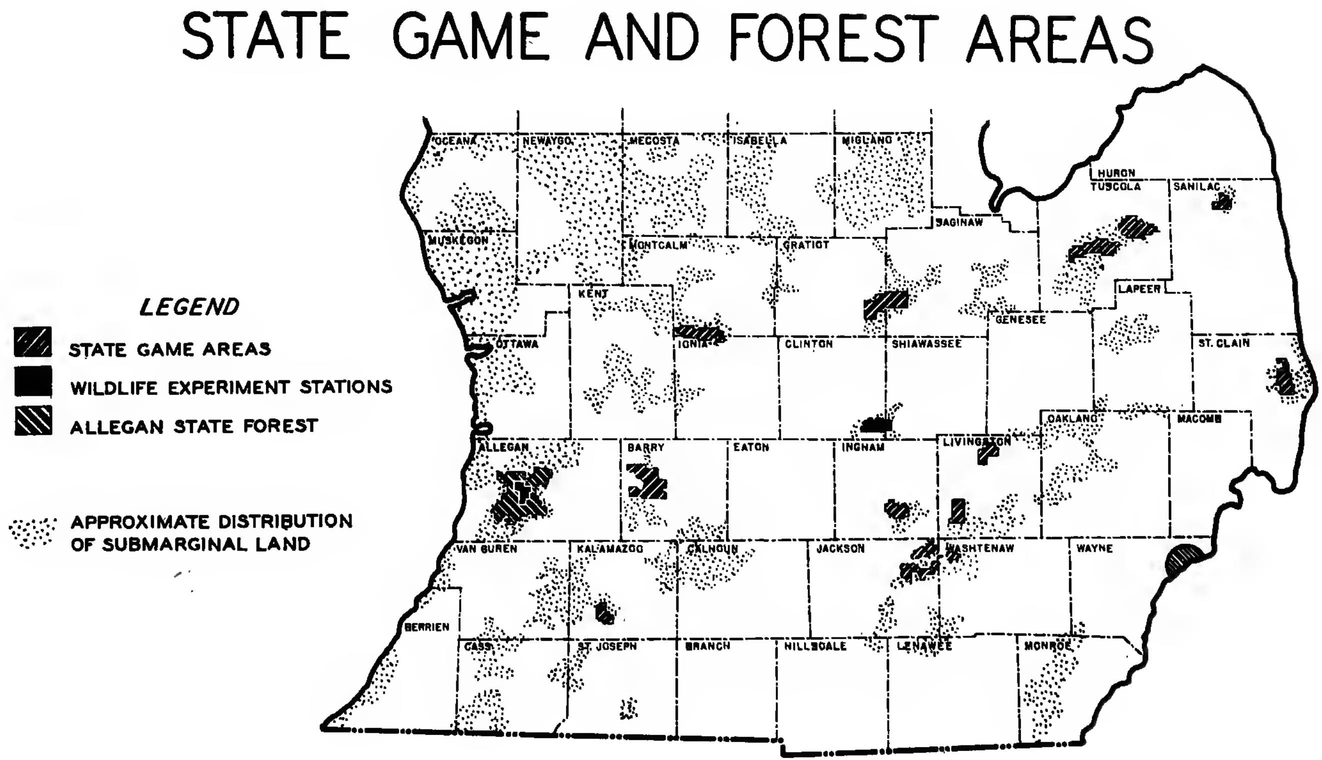


Fig. 107. Wildlife restoration and public game areas in southern Michigan. Tracts in Allegan and Jackson Counties have come under state administration from the federal government under long-term leases. Additions to all areas are being made by means of Federal Aid funds.

Improving extensive areas of this land for fox squirrels consists principally of the following measures:

1. Cutting openings in large blocks of woodland to increase the amount of edge.
2. Establishing forest cover in portions of large openings for the same purpose.
3. Planting a variety of shrubs and trees for increasing squirrel food supplies.
4. Managing woodlands for a high production of mast and hollow-tree dens.

The development of a game—recreational area may involve other improvements such as erosion control plantings, ground cover for rabbits, dams for ducks and muskrats, auto trails, picnic grounds, etc. It all will go together, but we need consider in detail only the more-squirrels measures.

Cuttings and Clearings

The creation of openings in extensive stands of timber is a squirrel management development that will sometimes pay its way. Wood products can be harvested, and such work will tie in well with rabbit management, since it leaves brush heaps, coppice, bramble thickets, and herbaceous growth as food and cover for cottontails.

On land devoted primarily to game and recreation, forest management should not include the removal of dead stubs, heart-rotted, hollow, or overaged trees. These assets to the squirrel program will be preserved wherever possible. Types of illegal cutting to be guarded against are timber poaching and bee-tree destruction. Both have been encountered at Swan Creek, and squirrel den trees which also contained bees have been felled at night at the Rose Lake station (fig. 110).

Aerial photos are an asset in planning the most desirable cover pattern in a given area. It will be necessary to run out boundaries of tracts to be cleared and to map plantations. The size of woodland units must depend principally upon topography. Edge is the objective, and with it a good variety of vegetational types. This idea and a proper regard for esthetics and erosion control probably are a sufficient guide for the present. Management of woodland cover is the most important key to general attractiveness in wild

Fig. 108. Land acquired by the state in public game areas is usually characterized by large blocks of open fields. These need to be broken up with shrub and tree plantings to improve conditions for squirrels, rabbits, and other wildlife.

land recreational projects. Thick grass and cool shade; berries, nuts, and flowers; wooded knolls and pure water—these are esteemed quite as much by humans as by the fox squirrel.

Maintaining openings

Any upland opening in southern Michigan that is left undisturbed will be invaded by shrubs and trees, and eventually become woodland. Thus a nicely mixed pattern of woods and open land is by no means a permanent condition. The maintenance of clearings can be accomplished in a number of different ways, and the method to be applied on any given site depends upon local conditions. If the topography is level so that a clearing in one place is as good as another, there may be no necessity for maintaining openings. New ones can be made by clear-cutting timber as old ones fill in. But in hilly tracts and areas dissected by streams, it will usually be best to have a fairly constant cover pattern in order to preserve the

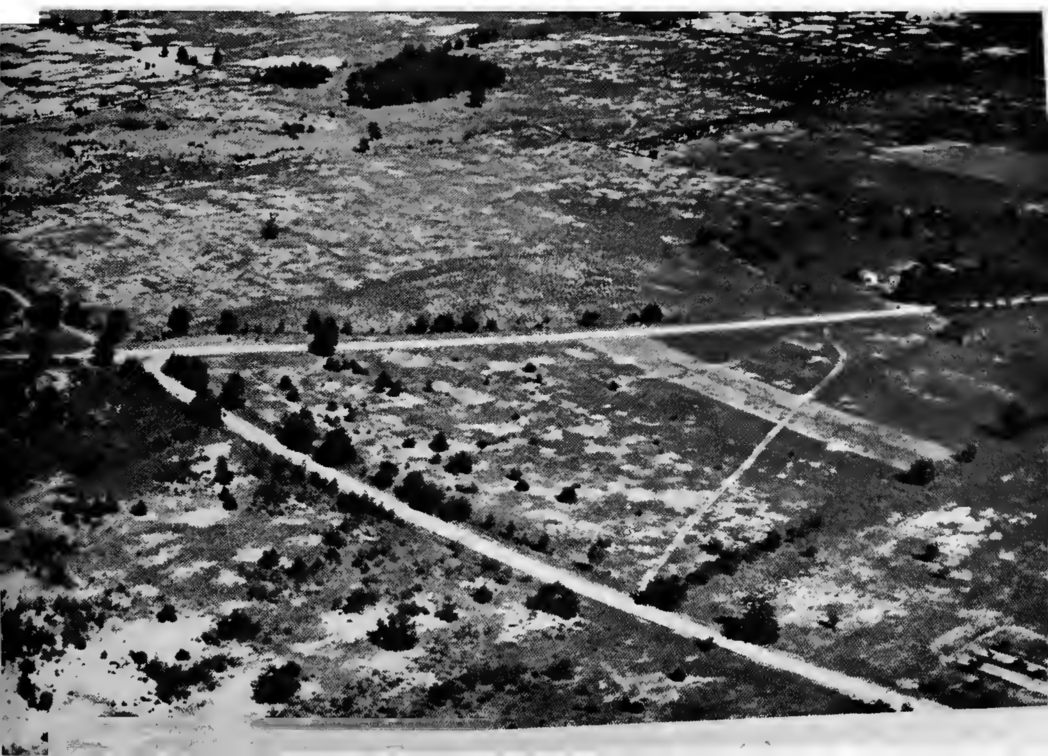
proper proportions of different forest types, good travel lanes, access to water, etc., and to keep slopes protected. In territory of this sort there are several possibilities.

Either cultivation or grazing will keep the land clear of most woody plants, but neither is very practicable. Removal of stumps and periodic breaking of the ground is far too costly. Pasturing openings might be feasible in close proximity to farms, but it involves the need for fencing, and the pasture value of coppice land is low.

One of the best tools for the low-cost maintenance of openings is fire. Forest fires have wrought such havoc in timberlands throughout the country, and burning has been so misused in grasslands, marshes, and farming areas that a considerable amount of prejudice has developed against burning anywhere. This attitude is somewhat short sighted. Simply because we do not like to have our homes burn down is no reason for avoiding the use of fire for heating. In a like manner, although there is no place for *uncontrolled* fire in wild lands, it would be foolish to shun its use where it is the cheapest and most effective method of accomplishing a sound objective.

Fig. 109. Areas such as this one in Allegan County will need careful long-time planning and development to become good game range.

Courtesy Soil Conservation Service



There are large areas in northern Michigan where, if any permanent openings are to be maintained for the encouragement of certain forms of wildlife, fire probably will have to be employed. All other methods are far too costly. This seems to apply also to southern game areas. A few men, at the proper time of year, in the right kind of weather, and with suitable equipment, can burn a large acreage in any desired units in a short period of time. Skillfully done, burning kills nearly all woody plants, or only the smaller growth, depending upon which is desired. The use of fire in southeastern (states) quail management is a highly developed technique (92) and there is no reason why the method should not take its proper place among the useful tools of game managers in other regions.

Doubtless a specialized method of burning will need to be worked out for use under southern Michigan conditions. Game management cuttings leave numerous brushpiles which it is not desirable to burn. There will also be thickets and isolated trees requiring protection. If fire is used, the wildlife manager must learn to burn *around* what he wishes to save and to kill out what he wants destroyed. Burning encourages the establishment of a sod, which woody plants invade with difficulty.

Fig. 110. Cutting bee trees at night on anyone's land is a fairly common practice in some places. This elm squirrel den was destroyed for a few pounds of honey (Rose Lake Wildlife Experiment Station).

Fig. 111. Old stubs and superannuated oaks are among our best assets on submarginal game areas. Both of these were squirrel dens of long standing (Allegan County).

Planting Trees for Squirrels

Tree and shrub planting is one of the most important of management techniques on land devoted to game. Plantations accomplish the same thing in abandoned farm fields that cutting does in solid stands of trees. They create more edge by adding strips and clumps of woody vegetation where none grew before. These can be selected and mixed to order from among the best food-bearing kinds. Some trees should be scattered or in small open groves where they will provide maximum seed crops. Others can be grouped to form the basis of future woodland units. Most planting should be done with a view to protecting watersheds, and gullies will sometimes need to be stabilized with soil-binding shrubs until forest trees become established. Especial attention should be given to providing communication lines in the form of strips of trees and brush between larger blocks of woodland. Frequently there are old fencerows grown up to woody plants which will function well in this way.

Fig. 112. For maximum food crops woody plants should be planted in the open. This serviceberry bore many times more fruit than nearby specimens in the woodlots.

A Sample Project

One of the best ways to visualize a southern Michigan development for game is to plan a specific project and to deal with the problems it presents. In the accompanying landscape sketches,

the "before and after" of a public game area are treated. The first sketch is a hypothetical tract of abandoned farmland that has proved too hilly and sandy for continued agricultural use. It might be a landscape in the Game Division's Barry County project. This sample area is characterized by old fields and eroded grades. On its overgrazed rocky hillsides, a few hawthorns are the only shrubby cover, although sassafras, sumac, and poplars are spreading out from the woods margin.

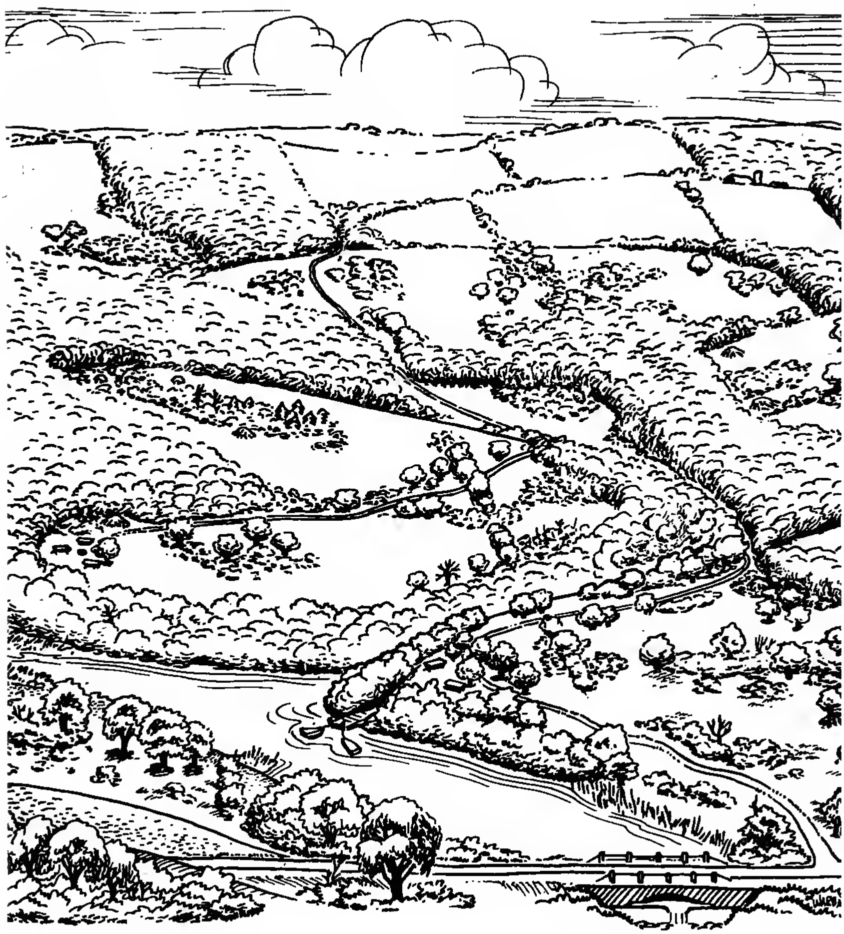
How this tract might appear 20 years later is shown in the "after" sketch. Old buildings have been torn down and fences removed. The stream banks, gullies, and inclines are now covered by a thrifty young forest. Nut and wild fruit trees are growing here and there along the woods edge. Lines of trees and brush extend between adjacent groves and along the pond and marsh border. The total amount of borderline between woods and open land has been more than doubled. This means that twice as many marginal trees can develop large spreading tops, and with increased exposure to the sun their mast yields will be greatly augmented. Other mast trees have been allowed to stand in the open where they

Fig. 113. In game areas small open clumps of nut trees located near woodlands will provide maximum supplies of squirrel food. They are also excellent for picnicking.

SOUTHERN MICHIGAN SUBMARGINAL LAND BEFORE———

These two sketches show the developments which might be carried out in an area of submarginal land which has failed for agriculture and which is now being devoted to the uses for which it is fitted—game, forests, and public recreation. This could be a landscape in one of the public game areas now being acquired and developed by the Game Division under the Federal Aid program. The major game crops in areas such as this are rabbits and squirrels. Since pheasants thrive best in good agricultural land, high populations can not be expected on fourth-class soils. In most of the game areas old fields are scarred by erosion and the marks of a type of use to which they are not adapted. Frequently the woodland and openings are both in relatively large blocks, and overdrainage is common.

——AND AFTER DEVELOPMENT FOR WILDLIFE AND RECREATION



As the area on the opposing page might appear 20 years after being acquired by the state. Solid blocks of woodland have been broken up by openings, and large fields have been in part planted to forest; this has created more edge between the woods and open land. Brushpiles and thickets have been scattered over the tract for rabbit cover, and numerous trees growing in the open near the woods margin produce abundant mast crops for squirrels. All eroded slopes are now protected by woody cover, and the continuous strips of tree growth form good communication lines for squirrels and other wildlife. A dam has created a pond, and other public recreation facilities in the form of auto trails and picnic grounds have been installed.

will develop similarly. The latter are for the most part small vigorous specimens which, as they grow, will send out deep roots to anchor them effectively against wind.

In the figure it is evident that openings have been created on the more level ground, leaving slopes protected by forest cover. Not only does this stablize the soil and prevent washing, but it slows up and reduces run-off of surface water, increasing the moisture content of the soil and making springs and streams more permanent. It also reduces the rate of silting in ponds and marshes and renders flowing water in the area less turbid and more suitable for desirable forms of aquatic life. The pond was formed by a dam across the fluctuating stream, and beside it a grassy plot among the trees is devoted to a picnic ground. The entire area is a pattern of interspersed woodland, sodded opening, and shrub thickets, which is maintained by the use of fire and other means.

Summary of Chapter Thirteen

Fourth class soils in southern Michigan are generally unsuited to present methods of agriculture. They are best adapted to the production of trees and use as recreational areas.

There are approximately 700,000 acres of submarginal land in lower Michigan, some of which is situated in units suitable for state acquisition and development. Smaller tracts near urban centers are frequently used as residential sites.

Fox squirrels and rabbits are the principal game crops in this type of land, since good pheasant yields can be expected only in good farming regions.

Developing submarginal projects for fox squirrel management is largely a matter of clearing and planting operations. The areas usually are made up of old farms and have large blocks of open fields. Fairly large units of woodland are also frequent. By cutting clearings in large woodlands the amount of edge is increased, and resulting brushpiles and coppice growth improve conditions for rabbits. Extensive plantings in large open areas add to woodland edge, increase the squirrel food supply, create ground cover, and control erosion. Other developments may include auto trails and picnic grounds.

Chapter 14

SPECIAL MANAGEMENT MEASURES

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SPECIAL MANAGEMENT MEASURES

THERE IS no doubt that the best management for squirrels, or other game animals, is by long-term development of favorable habitats. A woodland takes many years to grow, and the end-product must be planned far in advance.

Although there is no substitute for a good natural habitat, there are short-time management measures which may be useful in some situations. Winter feeding already holds a prominent place in the popular conception of wildlife management. Dens can be supplied by the use of nest boxes. Will sanctuaries give us more squirrels? And what about restocking? These management measures affect various wildlife species in different ways, and they must be evaluated for the fox squirrel in terms of its requirements and habits.

Winter Feeding

It has been demonstrated in preceding pages that to the fox squirrel an empty belly in winter may be the prelude to exposure, disease, and death. In an open winter with little snow and ice, the food situation in farmland is seldom serious. Fertile soils produce enough in the way of weed seeds and crop residues so that subsistence rations can be gleaned from fields and fencerows even when nut and acorn crops fail. In "wild" scrub-oak land this is not true, and a food scarcity may mean heavy mortality (p. 205).

It is evident that the problem is to provide *consistent* food supplies. The already-discussed improvement of habitat by encouraging nut-and-seed-bearing trees applies to both farm and wild land. Such a program should help to prevent extreme shortages. But when shortages do occur coincidentally with prolonged cold and deep snow, emergency feeding probably is the only remedy.

No implication is intended that winter feeding is a practical means of eliminating the effects of natural food deficiencies or hard winters on a statewide basis. Where conditions are so severe as to affect a large part of southern Michigan, it seems unlikely that any program could be applied widely and intensively enough to counteract the condition in an appreciable degree. For persons or

groups who are interested in specific tracts of land and willing to spend enough money and effort to "save" their squirrel crop, the situation is different.

Detecting food emergencies

A squirrel hunter can get some indication of whether a food crisis is imminent by examining his game. If hunting season animals have a good layer of fat beneath the skin of the belly, conditions probably are favorable. If practically all of the squirrels are emaciated, with no fat beneath the skin or in the body cavity, the situation is worth examining further. It is easy to appraise the amounts of standing or shocked corn near woodlots. Even if all signs point toward privation, it does not necessarily mean that squirrels will starve. If a bounteous food crop occurred the year before, there may be enough buried nuts and acorns still available to help tide the animals through. If the winter is mild, squirrels can find insects, seeds, and pits in the duff of the woodlot or in fencerow thickets. But a period of deep snow or ice can seal in these meager supplies. It is evident that in habitat with a poor variety of trees and little cropland the need for feeding is greater than in mixed woodland interspersed with grain fields.

Fig. 114. The condition of squirrels in the hunting season reflects local food supplies. Fat squirrels mean plenty of food and the prospect of a favorable winter and breeding season. A weight over 1 pound 12 ounces means prosperity.

R. D. Montgomery

Predicting mast failures

A shortage of acorns in trees belonging to the black oak group (black, red, jack, scarlet, pin) can, at least some of the time, be predicted a year and a half in advance, since these trees require that length of time for their fruit to mature. If twigs are examined in June, the presence or absence of this year's developing acorns and next year's stalked flowers is readily observed. In most regions a quick survey of trees along the road will be a good index of expected mast production. Trees belonging to the white oak group, as well as other nut-bearing species, can be appraised in early summer for the following fall. To what extent fertile flowers and developing nuts may prove abortive cannot be stated, but a certain amount of this does occur. Insects may reduce the crop to a considerable extent.

The frequency of food emergencies in Michigan is yet to be determined. Undoubtedly they come most often and are most acute in "marginal" squirrel habitat. But the object in winter feeding is not just to prevent starvation, but also to bring the animals through in sufficiently good condition to assure a high productivity of young. For this reason, a person sufficiently interested may want to do some feeding at times even in good farmland. Just how many more squirrels he will have to show for it can not be guaranteed; but the motives in winter feeding are not entirely mercenary anyway.

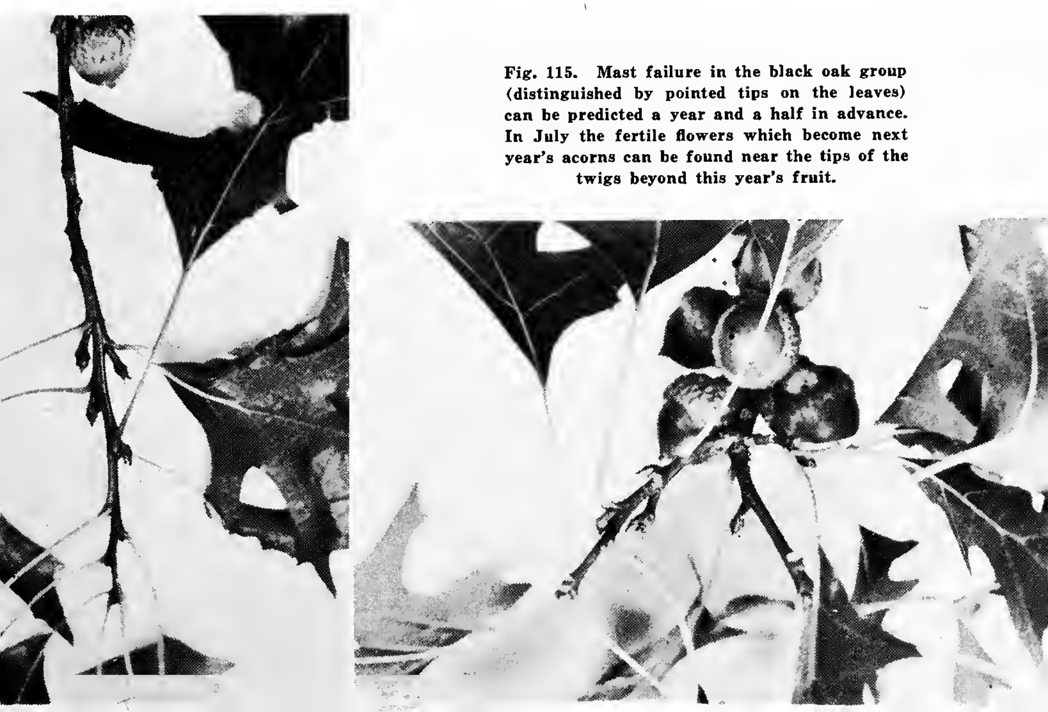

Fig. 115. Mast failure in the black oak group (distinguished by pointed tips on the leaves) can be predicted a year and a half in advance. In July the fertile flowers which become next year's acorns can be found near the tips of the twigs beyond this year's fruit.

Methods of feeding

Corn seems to be the ideal grain for feeding nearly any kind of wildlife in Michigan. It can be used on the stalk, in the shock, in ears, shelled, or cracked. For fox squirrels ears are better than shelled corn, for they can be carried from the feeding station or field to a favorite perch.

Food patches: A few rows of standing corn left in the field along a woodlot are excellent insurance against want for squirrels. Shocked corn serves the same purpose, although grain left in this manner is more subject to destruction by mice (70). Even though special food patches of corn are much patronized by squirrels, they probably are an expensive way to feed this species. In most cases it will be cheaper to grow corn in fields and place it in the woods when it is certain that an emergency exists. Deep snow often plays a part in food scarcities, and weather cannot be anticipated. It is also true that good food patches are most difficult to grow in the areas of poor soil where they are most needed.

Feeding stations: The most efficient way to feed squirrels probably is to put out ear corn in feeding stations when it becomes evi-

Fig. 116. Food patches of corn will be much patronized by fox squirrels, although there probably are more efficient methods of feeding.

R. D. Montgomery

Fig. 117. A wire basket or cylinder fastened to a tree and filled with ear corn probably is the best feeding device for fox squirrels.

dent that a food scarcity is developing. Following the mast shortage of 1940, the squirrels of an 8-acre woodlot at the Rose Lake experiment station were fed in this manner. Ear corn was provided in 10 chicken-wire baskets holding a bushel each and fastened to trees about 4 feet above the ground. A total of 22 bushels of corn were fed during the winter: 5 bushels on January 10, 8 on February 12, and 9 on March 27. At the end of the winter it was found that squirrels trapped in this woodlot averaged one ounce, or about 4 percent of their body weight, more than squirrels in woodlots where no feeding was carried on. This may or may not have been significant.

Feeding ear corn to squirrels need not be complicated. Merely dumping a bushel on the ground will work, and the animals will find it even after deep snow covers it. A shock or two separated into bundles and stacked here and there through the woods is also effective. A good way to feed husked corn is to nail a wire cylinder to a tree and fill it with ears, as in fig. 117. Other types of feeding stations are suggested by Chapman and Baumgartner (22). Squirrels are not backward about using the grain placed in hoppers for birds and need no extra attention if such feeding is being done.

It is evident that winter feeding of fox squirrels will be of maximum usefulness in those habitats where it is most difficult—thinly populated areas of light soil where the forest cover is primarily scrub oak. In most of the state's farming region feeding probably is not often necessary to prevent starvation, but it might improve the thrift and productivity of local populations when it is practiced in time of food scarcity.

Fig. 118. Old lumber or sawmill slabs are suitable material for making artificial fox squirrel dens.

Nest Boxes

Although squirrels can exist with only leaf nests as housing, studies have indicated that hollow-tree dens contribute to their safety and welfare. Again it is well to point out that long-time management—the preservation of hollow trees, is the best way to insure good nesting facilities. This applies equally to wild lands or farm woodlots. But a good den tree takes many years to develop. Where these are few or absent, nest boxes can be used as a substitute. Enough work on this phase of management has been done in the past 5 years to show that artificial structures are acceptable to squirrels.

Construction

Nest boxes for fox squirrels should be 10 inches to a foot square and 2 to 3 feet high. Near the top and next to the tree there should be a 3-inch hole. Boxes such as those in figures 118 and 119 can be made of any sort of scrap lumber or sawmill slabs.

Fig. 119. Nail kegs also make good nest boxes. The one on the right has a cover of tar roofing.

Ordinary nail kegs make excellent nest boxes. They can easily be fitted with wooden tops, and kegs with covers made of roofing have been in use at Rose Lake for four years (fig. 119). They can be nailed to a two-by-four which is spiked to the tree trunk, or they can be fastened to the tree with a short length of heavy galvanized wire. Nest boxes probably should be placed as high as possible. It is advisable to have them protected from below by one or more limbs. In this way the shooting or clubbing of boxes by unscrupulous hunters can largely be avoided. It is also well to put them in trees having few lower limbs and which are difficult to climb.

Squirrels will use much larger boxes than those described. At Swan Creek, boxes put up for wood ducks and raccoons were sometimes taken over by squirrels. But a nail keg or a square box of the dimensions given is large enough for this species. They frequently pack a box with leaves and make the nest in a cavity within.

Fig. 121. Constructing and installing squirrel nest boxes is an excellent 4-H project.

Use by squirrels and other species

In Michigan the first experience with nest boxes was obtained at the Swan Creek experiment station in 1939. Late in the winter 50 wood duck nest boxes furnished by the Farm Security Administration were installed in trees along two miles of bayou in the river-bottom. Aside from the wood ducks, we were interested in what use would be made of them by raccoons and fox squirrels. These houses were examined at intervals during spring and summer. In two of them litters of young fox squirrels were reared in spring, and by the end of summer at least nine were packed with leaves and contained fox squirrel nests. In addition to this species, the boxes were used by wood ducks, flying squirrels, red squirrels, woodmice, starlings, screech owls, tree frogs, and a raccoon. The record of these boxes has been much the same since 1939.

◀ Fig. 120. The best placement of nest boxes is high up, with branches to protect against missiles from below.

At Rose Lake in 1940 thirty-six nest boxes were installed in two oak-hickory woodlots. Table 11 gives the record of 24 of these through the spring of 1941. It is evident that fox squirrels, as well as other animals, often make temporary use of a box, actually sometimes more than one. In the absence of direct observation, the species using a box could usually be judged by the type of nest present, droppings, pellets, or food remains. It was found that fox squirrels commonly made nests of oak leaves. Red squirrels seemed to prefer dry grass, and flying squirrels often used shredded bark. The condition of the nest often made possible some estimate of how recently the box had been used.

Too little work has been done with nest boxes to warrant any broad conclusions as to the best species of tree and the situation preferred by squirrels. In the Rose Lake work, however, there has been proportionally more use by fox squirrels of boxes in black oaks than in other species, and the boxes highest up also seemed to be most attractive. Work in Illinois (55) has shown that these animals will use boxes placed in fencerows and osage orange hedges.

TABLE 11

Use of 24 Nest Boxes at Rose Lake in 1940-41

Woodlot No. 6 (installed July 1940)

Nest Box No.	*Species of tree*	*Height in feet*	Dates of examination *Oct. 4, 1940*	*Dec. 19, 1940*	*April 7, 1941*	*May 29, 1941*
1	White oak	42	Fox sq. present	Fly. sq. nest	Fox sq. nest	Red sq. nest
2	Black oak	44	Fox sq. nest	No nest	No nest	Fox sq. nest
3	Black oak	40	Not checked	Fox sq. nest	Fox sq. nest	Red sq. nest
4	Black oak	37	Scr. owl droppings	Scr. owl pellet	Scr. owl present	Scr. owl present
5	Black oak	33	Bees	Bees	Fly. sq. present	Red sq. (litter)
6	Small-fruited hickory	31	Red sq. nest	Not used	Red sq. present	Red sq. grass, leaves
7	White oak	43	Fly. sq. nest	Not used	Scr. owl present	Fly. sq. nest
8	White oak	43	Bees	Full of honey	Taken down	Replaced
9	White oak	43	Fox sq. nest	Fly. sq. present	Fly. sq. nest	Fox sq. present

TABLE 11 *(Continued)*

Woodlot No. 6

Nest Box No.	*Species of tree*	*Height in feet*	Dates of examination *Oct. 4, 1940*	*Dec. 19, 1940*	*April 7, 1941*	*May 29, 1941*
10	Black oak	44	Fly. sq. nest	Red sq. nest	Not used	Starling nest
11	Black oak	35	Fly. sq. nest	Fly. sq. nest	Fly. sq. nest	Fly. sq. nest
12	White oak	33	Feathers	Not checked	Not used	Not used
13	White oak	46	Feathers	Not used	Fox sq. (litter)	Fox sq. nest
14	White oak	47	Feathers	Red sq. nest	Red sq. nest	Not used
15	White oak	70	Bees	Bees	Bees	Bees
16	Black oak	46	Fox sq. nest	Fox sq. present	Fox sq. nest	Not used
17	Black oak	54	Fox sq. present	Fox sq. nest	Fly. sq. present	Not used
18	Red maple	48	Fly. sq. present	Scr. owl pellets	Fly. sq. present	Fly. sq. nest
19	Small-fruited hickory	30	Red sq. present	Scr. owl pellets	Scr. owl pellets	Not used
20	Shagbark hickory	40	Fly. sq. nest	Fly. sq. nest	Red sq. nest	Fly. sq. nest
21	Black oak	40	Red sq. nest	Red sq. nest	Scr. owl present	Not used
22	Black oak	46	Box out	Feathers	Fox sq. nest	Red sq. nest
23	Black oak	38	Fox sq.	Red sq. nest	Red sq. nest	Red and fly. sq. nest
24	White oak	44	Red sq. nest	Red sq. nest	Red sq. nest	Not used

Effectiveness

In January 1941 ten nest boxes were placed in a 5-acre woodlot at Rose Lake. Two months later half of them were in use by fox squirrels. Female squirrels bore litters in two of them. The woods contained only three resident females, and the other bore her litter in a white oak den. A survey of the woods showed that there were at least 14 natural dens and 17 leaf nests in it at this time.

Although fox squirrels have shown a definite liking for them, the effectiveness of artificial dens in producing more game has not

yet been demonstrated. Samples thus far have been small, and the presence of one or two more squirrels in a woodlot is no proof that nest boxes were responsible. A measurement of the exact extent to which these structures raise the carrying capacity of squirrel range can be obtained only when they are used on a large scale in an area deficient in dens. The Allegan oak woods seems to be well suited to this type of work, and such a project is now under way at Swan Creek. For the present it seems permissible to conclude that, since nest boxes are so obviously a satisfactory substitute for natural hollows, they must have a beneficial effect where tree cavities are few.

Cost

Nail kegs probably are the cheapest nest boxes which can be used. They are often obtainable free at hardware stores or lumber yards, and a keg can be made ready to put up in a few minutes. Boxes constructed of old lumber or slabs require more work and hence are more costly. The best estimate of cost for Rose Lake boxes was twenty-five cents for nail kegs and seventy-five cents for the square boxes. This includes materials and installing them in trees. Obviously, the more boxes built and installed at one time the cheaper they are. Good substantial boxes of rough-sawed 1½ inch lumber probably would cost near $1.00 apiece if made in quantity and all materials were paid for at market prices.

Nest boxes in the management program

It is not likely that nest boxes will ever be a practical substitute for natural dens in statewide management. The measure seems to be best adapted to the use of individuals who want dens quickly on a small area. Putting up squirrel boxes where there are few tree cavities should be an excellent 4-H project (58). It should also be well suited to the program of conservation clubs or other groups interested in managing squirrels on a particular piece of land. The long-time program can be aimed at a good natural habitat. The short-time program can include temporary measures such as nest boxes and winter feeding. Anyone who wants squirrels in his dooryard for their esthetic value should stand a good chance of accomplishing this by the judicious use of a nest box or two and a plenti-

ful year-round supply of food. He may not cause squirrels to be more plentiful. He may only move a couple from across the road. But that too is management.

"Predator" Control

A productive game range is practically always one in which large numbers of animals are able to survive in the face of such omnipresent factors as predation. It might be said that a good habitat controls its own predators.

As an example, in the best game habitats of southern Michigan there has been no sustained or intensive effort to kill off carnivorous birds and animals. Pheasants, rabbits, and squirrels are plentiful in many places where hawks, owls, weasels, raccoons, skunks, foxes or other meat-eaters are also common. Predators may help to limit the numbers of game species in some areas, but field studies indicate that to manipulate cover distribution or other conditions in such a way that prey animals (game) can escape their enemies will in the long run be more effective and cheaper than the sustained payment of bounties or other measures designed to hold down the number of carnivores.

It is particularly true of the fox squirrel that natural enemies account for only a small percentage of the annual increase. Occasionally it may be desirable to "control" the cat which captures young fox squirrels in the front yard or to eliminate a stray dog where it can be done conveniently; but in general there is no evidence that the killing of predatory animals will pay its cost in the management of game squirrels in southern Michigan.

Sanctuaries

Sanctuaries have gained wide popular favor as a means of increasing game. It is a common conception that animals build up to more than ordinary numbers on such areas and from these spread out to augment the population on surrounding hunted land. This idea has been fairly well tested for various species in Michigan. There has been a system of refuges in the north since 1916. The wildlife sanctuary law was passed in 1929, and in the southern part of the state there are now approximately 200 tracts closed

under this statute. Fox squirrels have been studied on a number of non-hunted areas.

Such investigations have shown clearly that populations on sanctuaries do not increase indefinitely. The Kellogg farm and Midland Park are permanently closed, and yet there was a conspicuous decrease in squirrels there from 1935 to 1936 (p. 92). Non-hunted woodlands on the Michigan State College farm were found to have fox squirrel populations comparable to the heavily-hunted woodlots at Rose Lake. Smaller areas kept in sanctuary at both experiment stations have shown no tendency to support an unusually large number of animals. To a great extent this same observation applies to other small game species.

It is obvious that a squirrel sanctuary differs from other areas only during the hunting season. During this period, if the sportsman harvests only a part of the annual "surplus," which would otherwise in the course of the year be lost to natural causes, then he is not limiting the population of squirrels. And the elimination of shooting could hardly be expected to increase the animals unless shooting was such a limiting factor.

When so many animals are harvested in one hunting season that they cannot be replaced by the next, that is overshooting. In such a case sanctuaries interspersed with the overhunted areas probably would help to neutralize the effects of excessive cropping. But the remedy for overshooting is not sanctuaries; it is to limit the kill. In any large area greater production can surely be obtained by leaving a breeding reserve sufficient to stock the habitat completely, rather than by setting aside a portion of the land to be closed to all hunting.

Limiting the kill is also more economical from the administrative standpoint. On a statewide basis, bag limits and controlling the length of the season are effective means of balancing intensity of hunting against the game supply. If, over a large area, there were no other means of preventing the overshooting of squirrels, then a system of closed areas might be worthwhile, even though it involved the expense of posting and patrolling. But, fortunately, there are better methods.

Closed Seasons

Statewide closed seasons (i. e. years with no hunting at all) are subject to much the same objections as sanctuaries. Those who favor this idea intend nearly always to allow game populations to "build up." Implicit in this attitude is the assumption that hunting is responsible for holding populations at the existing level. It is quite safe to say that this is not true of any of our farm game in Michigan. The administrator and the wildlife manager do not knowingly deviate from the principle that hunting-season crops must be a part of the yearly "overproduction" of each species; that is, animals which would otherwise be lost to natural causes before the next generation matures. Hunting regulations are, or should be, enacted with this in view. If a hunted game population is able to hold its own or increase from one year to the next, that is good evidence that the hunter is not getting too much. If existing regulations do not prevent overcropping, they should be changed. But to substitute a closed season at intervals to allow the squirrel population to recover from the effects of mismanagement would be poor business.

By an unanticipated action on the last day of the session, the Michigan legislature closed the 1938 fox squirrel season. There is no doubt that squirrels were sufficiently plentiful in that year so that sportsmen of the state could have killed half-a-million-odd animals without harm to the next year's supply. Even though the species increased in 1939, it is quite evident that the lost crop of 1938 was never recovered by the hunter. Population data at Swan Creek (p. 87) show that fox squirrels did increase from 1938 to 1939. But the species also increased approximately the same amount from 1939 to 1940, even though a crop of over 600,000 was taken in 1939, and conditions adverse for the survival of young animals developed in the summer of 1940 (p. 128). The evident steady increase in fox squirrels from 1937 through 1940 leaves an unmistakable impression that the closed season of 1938 had very little effect on the population trend.

If some catastrophe were practically to wipe out the state's fox squirrels, a closed season would certainly be in order. Under such conditions the range would be understocked, and there would be a good chance for every animal not killed to survive. All squirrels could be considered a part of the breeding reserve. But, barring any widespread decimation of Michigan game squirrels, there ap-

pear to be few situations in which we could not employ a better measure than the closed season. It is probable that the research program now in progress could easily detect and give forewarning of any real need for such a measure.

Artificial Stocking

The general theory of artificial stocking as a means of maintaining game populations was discussed in the introduction (p. 11). There it was emphasized that restocking is not the answer to the more-game problem, since it does not cure the habitat deficiencies which are responsible for low populations. By habitat deficiency we mean, of course, anything in the environment, permanent or temporary, which prevents animals from reaching maximum numbers.

In the natural course of events each year the breeding population of any animal far "overstocks" the habitat. By the next breeding season, if the species is not increasing or decreasing due to fluctuating factors (such as mast yields, etc.), animal numbers will have been reduced by natural controls to about the number of the original breeding stock. This represents what the habitat has been able to support under those conditions. Michigan investigations on pheasants and rabbits indicate that restocked animals are in most cases less able to survive natural controls than wild-reared individuals. The cost of rearing animals on game farms or transferring wild-trapped animals to understocked habitats is prohibitive even if most of them did survive.

Under favorable conditions nature produces with such prodigality that our management dollars are much better spent on semipermanent improvements in the environment than in transitory efforts to "over-stuff" poor range with coop-reared or wild-trapped individuals. In a manner of speaking, it is much cheaper to get the necessary large numbers of rabbits, pheasants, and squirrels by buying stock in the factory (habitat), increasing production facilities, and turning them out wholesale in "carload" lots, than by paying high prices for them, one by one, in the retail stores (game farms).

Unoccupied range

Although the restocking of occupied range has no place in the squirrel management program, under some conditions the establishment of the species in unoccupied favorable habitat may be successful. As an example, there were no fox squirrels in the Charity Islands until 1896 (111). At that time two pairs were released there. These animals increased to such an extent that they had become a nuisance by 1902. During the winter of that year all of them died. This is another good illustration of the fact that hard winters limit the carrying capacity of our northern squirrel range. It is also noteworthy that a very small number of breeders were sufficient to stock this unit of *unoccupied* and temporarily *favorable* habitat. Had conditions remained suitable, there is no reason to believe that additional releases would have been necessary.

An example of successful stocking was the establishment of what were evidently midwestern fox squirrels in Boise, Idaho. These animals now occupy a few square miles of favorable range in and around the city. An attempted stocking in 1917 was considered a failure, but subsequent efforts appear to have been successful. Just when the animals were liberated is not known (72).

Wherever range becomes available adjacent to already populated areas, animal populations spread out and stock the new habitat. That happened among Michigan fox squirrels in the last century. Where favorable range is not continuous with occupied territory, the introduction of a species can be accomplished by importation. Whether it is justified or not depends upon many factors, and these should be carefully studied before such a move is made. Animals which are good citizens at home may become a costly nuisance when introduced into a plant and animal association to which they are not native, as experience with the rabbit in Australia, the muskrat in Europe, and the starling and house sparrow in the United States will attest.

Where Short-time Measures Belong

It is evident that some of the measures just discussed may have a place in the management program for a specific area. Anyone who is sufficiently interested probably can find a way to feed squir-

rels in a specific woods when food is scarce. This can be done in spite of the fact that it would not be possible to feed them in every woods in the county. Likewise persons interested in improving a given tract for squirrels may be able to furnish nest boxes, even though artificial dens cannot be installed in every woods in the state where hollow trees are few. In some areas hunting may be inconsistent with other uses, and it might be desirable to create sanctuaries for reasons other than game production. It is also conceivable that the transfer of a few breeders to squirrelless islands or similar areas of unoccupied range might occasionally be worth while.

In general, however, squirrel production in Michigan will depend upon development of wise land-use policies to assure the natural growth of favorable habitats wherever there is a place for them. To see that 200,000 farmers get information on the profitable use of their woodlands is vastly more important than to install nest boxes in a few areas, or even to develop the relatively small acreage that will come under state ownership. The widespread avoidance of destructive and unprofitable practices, such as woodland grazing, will ultimately accomplish much more than the intensive management of a few scattered tracts by enthusiasts. The biggest management job deals not with squirrels directly, but with human beings and their pocketbooks.

Summary of Chapter Fourteen

Short-time management measures, such as winter feeding and artificial dens, are suitable for application on a relatively small scale by individuals interested in specific areas and not too concerned with costs. But long-time planning and developments involving plantings and cuttings are more practicable for large-scale projects. They should ultimately achieve the same ends.

Ear corn fed in wire baskets fastened to trees, or in shocks merely dumped in the woods, will tide squirrels through a winter of low food supplies.

Nest boxes made of nail kegs, sawmill slabs, old lumber, or other material are suitable substitutes where hollow trees are absent.

Predator control and artificial stocking have no place in southern Michigan squirrel management. Neither is a substitute for a favorable habitat, and neither is necessary in a favorable habitat.

Sanctuaries have no beneficial effect unless squirrels are being overshot. And in such a case, measures such as small bag limits or a shorter season would be more economical.

A statewide closed season would be desirable only if fox squirrels suffered a widespread decimation. Otherwise, as in the closed season of 1938, they represent only a loss to the hunter.

Chapter 15

NUISANCE SQUIRRELS

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NUISANCE SQUIRRELS

OF THOSE animals living in close proximity to man, there are few that do not occasionally harm property or otherwise become a nuisance. The fox squirrel is no exception, but for most of the state the Department of Conservation gets few complaints of damage in proportion to the numbers of this species. The general attitude of landowners toward fox squirrels is that they "like to see them around" and do not mind paying a little for the privilege.

Squirrels are guilty of several kinds of damage. They have a well-developed taste for the seeds of green apples and pears (fig. 122), and some people object to their digging up the sod of meticulously kept lawns to bury food. They have been known to destroy geraniums in a cemetery. At times they exhume the kernels of freshly planted corn and eat them. In nurseries or reforestation projects they are expert at finding nuts which were planted to become seedlings. Occasionally they get into the attics of summer cottages or homes in town, lay waste the popcorn stored there, and otherwise make themselves unwelcome. Often, however, they are blamed for such misdemeanors when red or flying squirrels are the true culprits.

There appear to be just two types of damage which are worth discussing at any length—their depredations on field corn and the girdling of trees.

Damage to Field Corn

Corn in the milk

As was observed by Kennicott a century ago, fox squirrels are inordinately fond of unripened corn. In late summer or fall, nearly any cornfield bordering a woodland in southern Michigan will show evidence of their work. In fact raccoons are sometimes blamed for this type of misdeed on the part of fox squirrels.

Squirrels open and sample many ears on the stalk (fig. 123). Others they gnaw off and carry to a perch in the woodland. On the wooded dike bordering a lowland cornfield at the Swan Creek

farm there were trees under which, in season, as many as a dozen stripped green ears could be found. Although this kind of work is widespread, there is seldom enough of it in any one field to make much difference in the harvest. A bushel of corn may be taken here and there, but most farmers do not consider such a loss to be worth control measures—especially where so popular a sinner as the fox squirrel is concerned.

It is easy to understand, however, from the corn that can be sampled or destroyed by a few of these animals, what the pioneers had to contend with from the hordes of gray squirrels which in times of abundance inhabited the forest surrounding their fields. Referring to conditions in Indiana, Hahn (49) wrote, "Judge Banta, in the history of Johnson County, states that in 1821 four families living in White River Township did not succeed in saving a single bushel of corn from the squirrels." Kennicott (64) made similar observations, "Fields of corn, and occasionally wheat, are much injured or entirely destroyed by them. I am informed that persons have sometimes kept watch in their fields to drive them off, and thus prevent the destruction of the whole crop."

Present conditions in Michigan do not call for any such measures as this, owing to the smaller numbers of the squirrels and the fact that damage is diluted by being spread out over many more fields.

Ripe corn

Although the greatest inroads are made on green corn, when ripened grain is allowed to stand out over winter, appreciable quantities may be taken. In the winter of 1940-41 at the Rose Lake station, there was evidence that several squirrels took up temporary residence in 2 acres of trees beside standing corn and lived upon it during most of the cold season. Under a single hickory 136 cobs had been dropped (fig. 124). The animals commonly get into shocks and carry ears to the woods. I have tracked squirrels a mile from a nest to a cornfield in the Allegan area, and they were

Fig. 122. In summer fox squirrels sometimes make themselves unwelcome by opening green apples or pears (left) for the seeds. Red squirrels do this even more commonly.

M. D. Pirnie

Fig. 123. Fox squirrels are fond of green corn, and they sometimes damage much more than they use.

carrying whole ears of corn more than half a mile from the shocks. Sometimes Conservation Officers are called upon to investigate this kind of damage, and permits may be issued to kill fox squirrels. But more often the farmer pays the tribute and forgets the matter.

All three kinds of corn damage—digging up seed, opening green ears, and taking ripe corn in the fall—may be costly in the case of choice hybrid seed corn or where quantitative experiments are being carried on. In the experimental plots on the Michigan State College farm, squirrels have been a perennial problem. No good repellent or other practical remedy for the trouble has been worked out. But in 1941 the woodlot harboring most of the squirrels was trapped intensively and all fox squirrels taken were removed. During that summer, there was practically no damage to the nearby corn plots.

According to our experience, a woods could probably be kept free of squirrels or nearly so, by operating a box trap (p. 80) per 2 acres for about 3 weeks in June and for 3 or 4 days every second week during the remainder of the season. If the values involved are sufficiently large to justify such an expenditure of effort, the method is probably the best way known at present to protect crops.

Squirrels should be removed to a distance of 4 or 5 miles. Although it is not certain how far fox squirrels will return to their home woods, gray squirrels are known to have a well-developed homing instinct (61).

Fig. 124. Fox squirrels regularly patronize fields of standing corn in winter. Under such a feeding tree as this 136 stripped cobs were counted. Usually corn damage is not sufficiently serious to require control.

Tree Damage

Probably the least popular habit of the fox squirrel in Michigan is that of removing bark from hard maple trees during the winter. Where this occurs in towns or around cottages and country homes, valuable trees may be severely damaged. One of the areas where hard maple damage has been most conspicuous is along Lake Michigan in Van Buren and Berrien Counties. The situation there was studied, as a part of the Swan Creek program, in the winter of 1938-39.

The woodland of the lake margin consists for the most part of hard maple with varying mixtures of beech, red oak, hemlock, poplar, and other species. This growth occurs on stabilized dunes in a narrow strip along the lake and forms a favored location for cottages and homes. Local observers in this region have reported that every winter there is some girdling of hard maples, but in certain years the damage is greatly increased.

In 1938-39, it was especially bad in the vicinity of Covert Township Park and privately-owned Palisades Park. Conditions there were investigated on two occasions during January. Squirrels were removing bark for the most part from limbs less than 4 inches in diameter, and some of these were completely girdled and killed (fig. 125). Others had only patches of bark gone and doubtless recovered. The damage to many trees was restricted to a few limbs, although the trunks of smaller specimens were sometimes laid bare. A few excellent shade trees on cottage lawns were destroyed, and others were sufficiently damaged to change their appearance. In many places, bushy tops and dead limbs gave evidence of similar work in years past. Property owners who suffered damage of this kind considered the squirrels a liability that quite outweighed their esthetic value.

Another type of tree injury was observed in Gratiot County by H. D. Ruhl and Ned Dearborn in 1929. The work was principally on red maples, but a few beech and ironwoods were also damaged. Patches of bark were removed from the roots or a foot or two above the ground. It was exceptional for a tree to be attacked on the upper branches. Small trees were killed in a single year, and larger ones were completely girdled after several years. According to the owner, damage in this woods occurred in the summer months, beginning in late June, and continuing through July and probably into August.

Fig. 125. Winter damage to hard maple trees is among the most objectionable habits of the fox squirrel. Valoable shade trees are sometimes destroyed in this way.

What a squirrel derives from this bark-cutting activity is not always evident. Both Kennicott (64) and Seton (86) cite the liking of this species for sap, and the latter especially mentions sugar maples. In the winter girdling of maples in Palisades Park the bark was reduced to fine chips, and it appeared likely that the animals were after the sweet sap of these trees, but they might have eaten the cambium layer. In 1926 M. R. Webb of the Game Division observed spring fox squirrel damage to hard maples in Muskegon Park and concluded that it was the inner bark that was being eaten. In the Gratiot County case the animals may have been impelled by some other motive, possibly a mineral deficiency or something of that nature.

When winter squirrel damage becomes conspicuous, there are usually reports that the animals are starving and are using bark as a last resort. This was not true in any case studied. In Palisades Park the animals had dug large numbers of red oak acorns from beneath the snow, hulled them, and left the meats with only a nibble or two gone. This species of acorn is not a favored food—it appears to be used more in some areas than in others—but the

squirrels in question certainly were not starving. Attempts were made in Covert Park and the village of Saugatuck to prevent damage by feeding the animals ear corn. They took the corn, but continued to chip bark as before.

In areas where it is practicable, probably the best remedy for trouble of this kind is to encourage heavy hunting. Most of the barking is done during January and February, and if the animals are well thinned out late in the open season, damage probably will be minimized. It can be expected that a new crop of squirrels will be on hand in another year and that the measures will need to be repeated. Trapping or shooting in winter probably will help, but such expedients are expensive, and the necessity for them is not usually known until the harm has reached serious proportions. Work of this kind, of course, needs to be authorized by the Department of Conservation upon the recommendation of the local officer.

Department Policy on Damage

There is a common misconception among people sustaining damage to property by wildlife that the Department of Conservation assumes financial responsibility for their losses. There is no authority to use game or other funds for this purpose. If an individual proves, upon inspection by the local Conservation Officer, that he is suffering real damage by wild animals, he can apply for and receive a permit to kill necessary numbers of the offending species. In cases where it is practicable, animals may also be live-trapped and moved to other areas. This is the extent to which the Department of Conservation is empowered to deal with such matters. What the boards of supervisors of individual counties may wish to do with their own funds in the way of compensating for damage is not related to department policies.

Summary of Chapter Fifteen

Fox squirrels are frequently guilty of property damage, but this is usually on a small scale and not worth control measures.

The most common misdeeds of these animals on the farm are depredations on field corn. Green ears are frequently opened or carried away in the fall, and ripe corn may be removed from the shock in midwinter. Occasionally, seed corn is dug up.

The most serious complaint against fox squirrels is the destruction of valuable shade trees. They are fond of hard maple bark in January and February and sometimes girdle limbs or trees sufficiently to kill them.

Damage by wildlife should be called to the attention of the Conservation Officer. Upon his recommendation a permit can be issued to trap or kill offending animals, but state funds can not be used to compensate individuals for damage.

Chapter 16

HUNTING, REGULATIONS, AND ENFORCEMENT PROBLEMS

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HUNTING

AS IN THE case of the proverbial cat, there are many ways to kill a squirrel. But if sport is the object, how it is done largely determines the value of the animal to the hunter. Hence hunting practices are worth consideration in management planning.

Hunting Practices

Where food is the primary objective, wild animals are commonly taken by the easiest, rather than the sportiest, method. But among the midwestern "meat" hunters of a century ago there seem to have been ideas about how a self-respecting rifleman got his squirrels.

Where the term "creasing" came from I do not know. But it is said to have referred to the technique of grazing a squirrel's skull with a rifle ball, enough to cause a concussion but not enough to mutilate the carcass. Even today, the "purist" squirrel hunter is likely to leave the head attached to the front half of the body and boil it along with the rest. The old-timer maintains that the tongue, cheek-muscles, and brain are the most toothsome portions of the animal. There is no doubt that this method of dressing and cooking squirrels was common in times past and that it was considered undesirable to shoot up the victim's head.

"Barking" is another technique sometimes described in stories of pioneer life. The idea was to shoot through the bark of the branch upon which an animal was lying and stun the victim without breaking its skin. A careful stalker can frequently catch them sunning, and nearly anything should have been possible when grays and blacks were so plentiful that a meal for a large family could be shot from one tree. The squirrel rifles of pre-civil-war times were respectably accurate up to 60 yards, and there is ample proof that the users knew their business. Many Union and Confederate sharpshooters got their training on the squirrels of the midwest. The importance of these animals in the diet of the pioneer has perhaps not been sufficiently appreciated. In their frequent periods of abundance, they were one of the most dependable sources of meat for the early hunter. Seton (86) states that as recently as the early part of this century, logging camps in Missouri employed hunters to shoot squirrels for meat.

Guns and dogs

Today the 22-caliber rifle is the weapon *par excellence* for squirrels. Perhaps many hunters do not know that an efficient repeating rifle and telescopic sight can be had for as little as $25.00. For a hunter to sit in the leaves on an autumn day with his back to a tree and wait for a 2-pound fox squirrel to emerge from its den, is a way not only to hunt but to learn things about the habits of wild animals.

Most Michigan hunters own shotguns, and that is undoubtedly the most useful single gun for the Nimrod interested in small game. It is the proper weapon for pheasants, rabbits, waterfowl, grouse, etc., while uses for a rifle are much more limited. Hunting squirrels with a shotgun is by no means poor sport, but many hunters are due to find that they have been missing something when they finally discover that natural combination, the fox squirrel and the twenty-two.

Squirrel dogs are not common in Michigan today. Many breeds can be trained to trail and tree either by sight or scent. The addition of a dog to squirrel shooting accomplishes the same that it does for any other kind of hunting. A part of the hunter's pleasure comes from the action of his partner in the chase. A squirrel treed by a dog is not usually difficult to bag, although the animal must be stopped before it can make its way through the trees to a den. Dogs certainly help to avoid the loss of cripples, and the chase is often enlivened by a squirrel's proficiency with teeth and claws.

Fig. 126. To squirrel hunting a dog adds the interest of a companion in the chase. They are not now in common use in Michigan, although many breeds can be trained for this type of hunting.

The value of an animal largely depends upon the use that is made of it. In Michigan the fox squirrel is more a source of sport than of meat. Hence the emphasis has been upon fall hunting seasons never earlier than October. To the pioneers the squirrel was primarily a meat supply, and this is true in some parts of the midwest today, where it is hunted in summer when young of the year are most tender.

Nest shooting

Nearly any squirrel hunter will agree that nest shooting is a fairly common practice in southern Michigan. If he hunts for a while without seeing any game, and there are numerous large suggestive-looking nests in the trees, the hunter may begin to wonder whether the animals are not holed-up in leaf nests at that particular time. He puts a charge of number sixes through a nest, with the idea that if any "kicking around" occurs, he will climb up and get his squirrel. Now and then an animal stung with shot will leave the nest to be shot again, and this encourages the practice.

As a part of the Allegan squirrel work, I tested this kind of shooting during two winters. Thirty-three large nests were shot into with a 16-gauge gun and number-6 high-velocity ammunition. After each nest was shot, a few minutes were devoted to watching for any sign of life, and then the tree was climbed and the nest examined. My dog watched the proceeding prepared to attend to any cripple that leaped to the ground. Four of the nests contained squirrels. In no case could the presence of the animal be detected from the ground. Three of the squirrels were only injured and leaped from the nest when I reached it. They were caught by the dog. The fourth squirrel was nearly dead when taken from the nest.

This is a small sample, but the work did show that a nest-shot squirrel is likely to remain quiet and not betray its presence. Most hunters would pass on with the idea that the nest was empty and leave a wounded or dead animal to be wasted.

There is no information to show how destructive nest shooting is in relation to the state's squirrel crop. The most that can be done at present is to point out its effect. It is something that the progressive sportsman should know about and avoid in the interest of efficiently utilizing his game crop.

Hunting Conditions

Habitual squirrel hunters are much concerned about conditions in the woods. Early frosts kill the leaves, and strong winds bring them down. Dry days in late October make walking noisy; but it becomes equally easy for a quietly-sitting hunter to hear that stirring in the crisp layer underfoot which signifies a fat fox squirrel rousting about for his winter provender.

Work at Rose Lake indicates that the earliness or lateness of the first killing frost is probably the most important single condition which determines whether the Michigan hunter will get his proper quota of the fox squirrel population. Frosts coming before or early in the squirrel season, followed by a windy day or two, "open up" the woods and increase visibility well beyond accurate gun range. On the other hand, if frosts come late, and oak leaves are not shed until late October or November, the percentage of the squirrel population that can be liquidated as sport and meat during the open season is markedly reduced.

NEST SHOOTING

Shooting into squirrel nests is a fairly common practice among hunters.

But tests have shown that a shot squirrel often remains in the nest giving no sign of its presence. The hunter seldom climbs the tree to make sure.

This kind of hunting is poor sport and wasteful of both ammunition and squirrels.

To illustrate this, table 12 gives some hunting-season statistics for the first three years at the station. The figures on box-trapping before the hunting season are used as an index of the relative numbers of squirrels available to shoot, although the number of animals caught in 1940 seems to be low.[27]

The point of chief significance here is the small number of fox squirrels shot in 1941. Trapping records showed that the species was plentiful on the area, but hunters were not rewarded to the extent that they were in any of the other three years. The obvious reason was poor visibility in the woods. The first killing frost did not come until late in the season, and oak leaves did not begin to fall until the end of October. Conditions were in marked contrast to the year following (1942), when an unusually early killing frost came on September 29. This was followed in the first days of October by the strongest winds since 1910, giving unusually good squirrel hunting conditions throughout the open season.

There is no doubt that widespread conditions of poor visibility will prevent the hunter from getting all of the available squirrel crop. It is probable that this factor enters to a significant extent into the lowered statewide kill of 1941, although a reduction of squirrels undoubtedly occurred in some habitats (p. 89) and probably was more important.

The average date of the first killing frost in most of southern Michigan comes between October 5 and October 10. It is only in the extreme southeast and southwest that it comes as late as October 15 (97). Records from the East Lansing Weather Bureau indicate that in the 32 years since 1910 there have been 9 seasons in which the first killing frost came on or after October 20, which is probably sufficiently late to interfere significantly with squirrel hunting. The frequency of this occurrence probably does not, in itself, justify a later squirrel shooting season (p. 340), but it is a factor to be considered in case other conditions make revision of hunting season dates desirable.

[27] A possible explanation for this can be offered for what it is worth. The fall age ratio of that year showed only 25 percent juveniles. The annual movement coming at that season involves young animals to a great extent. Hence it is possible that the number of squirrels moving through the Rose Lake area was abnormally small in 1940. There is no question that in most years many non-resident individuals are marked during this trapping period.

TABLE 12

Squirrel Harvest at Rose Lake in Relation to First Killing Frost and the Fall of Oak Leaves

Year	*Date first killing frost*	*Hunting conditions*	*Squirrels trapped*[28]	*Squirrels killed per 100 acres woodland*
1939	October 1	good	—	58
1940	October 16	good	39	42
1941	October 27	poor	110	42
1942	September 29	good	168	107

Overshooting

In the 1939 hunting season a 9-acre woodlot at Rose Lake appeared to have been "shot-out." At least a dozen squirrels were taken there, and in early winter there were no residents in the woods. During the year following it was repopulated. In spring there were 4 residents, and by August there were 19, with 7 summer non-residents accounted for. In the hunting season 11 fox squirrels were shot in the woods.

Under Michigan conditions the repopulation of overshot woodlots is fairly easy because of the general abundance of this kind of cover. In Ohio, Baumgartner (11) found that such woodlands were much less likely to be immediately repopulated owing to the great extent of cleared land in some localities.

It was shown in Chapter 6 that during September and October fox squirrels are particularly active in traveling from one woods to another. This "reshuffling" of population continues into the hunting season. Local concentrations may be found in especially good feeding areas (p. 95), and in such places it is possible to shoot many more squirrels than were raised there. Other tracts, where there is little food, may be largely evacuated by their summer residents. Obviously, under these conditions it is difficult to harvest squirrels on an acreage basis. It would be convenient if we could say to a farmer, "When squirrels are abundant, shoot one to the acre." But that is not realistic.

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[28] This is the number of fox squirrels caught on 800 acres of farmland containing 102 acres of woodlot in 7 units. The figure is used here as an index of animals available to shoot. It can not well be used as a population figure, since the trapping was done in the month preceding the opening of the hunting season (Oct. 15), when the animals were at the height of their annual movement (p. 151).

Areas of "wild" land evidently are being hunted much less intensively than farms. At the Swan Creek station, on 3,200 acres of scrub oak, old fields, and riverbottom, 156 hunters took 224 fox squirrels in 1939, and 119 hunters took 112 in 1940. Many of these hunters were after rabbits, or pheasants on the Swan Creek farm, but it is evident that there was little squirrel hunting in proportion to what the land could have furnished. Probably hunting of about this intensity prevails in much of the relatively continuous woodland along southern Michigan watercourses.

To some extent hunting probably is self-regulatory. In tracts with few squirrels, hunters get small returns and consequently spend less effort than in areas where shooting is good. A resident owner may hunt his own woods persistently regardless of conditions, but most sportsmen are attracted where there are reports of "lots of game." Michigan's hunting season lasts but 3 weeks, and there probably are few woodlands where squirrels are seriously depleted in that length of time. Some farmers esteem fox squirrels

Fig. 127. To some extent hunting is self-regulatory. Woodlands with an abundance of squirrels attract the heaviest hunting; and where populations are low there is least danger of overshooting.
W. W. Shapton

along with quail as desirable citizens and do not permit them to be shot. There are many farms closed to all hunting. Under present conditions it seems safe to conclude that more woodlands are under-hunted than over-hunted, and that the mobility of squirrel populations is fairly efficient in undoing any ill effects of local overshooting.

The Hunter's Share

On a basis of the breeding, population, and hunting data on this species, it appears that hunters take about one-third of the potential yearly population of fox squirrels (p. 100). This is more likely to be an overestimate than an underestimate. Of course, not all squirrels live until fall, and those that do not are a part of the annual natural mortality losses. The point is, that if the hunter gets a third of the *potential* maximum, then he must take more than a third of the actual *existing* fall population.

There are numerous variables which can not at present be fully evaluated. But available information indicates that a kill of 40 percent of the fox squirrels on an area in October is not unusually large for heavily-hunted woodlands. The maximum number it would be possible to take without reducing next year's crop will have to be determined by experimenting with a large area under full control. I suspect that the answer will be not less than half.

To many this will be a somewhat startling statement. The figure appears to be very high. But reflection on some of the population changes we have witnessed makes it more credible. When small breeding stocks were favorably situated, squirrels attained an unexpectedly large production of young by more-than-usual summer litters, or by breeding at an unusually early age, and through good survival of juveniles (pp. 113, 129). Small populations compensated for their smallness by increased fecundity. On the other hand, large breeding stocks were not characterized by high achievement. In 1940, when the food situation deteriorated, it evidently was competition between large numbers of old animals and young of the year which caused the latter to decline in numbers through the summer (p. 128). Briefly stated, small populations have responded to favorable conditions by an accelerated rate of reproduction; and large numbers under unfavorable conditions have been

capable of only a reduced rate of increase. Obviously, the important thing is the condition of the habitat.

Those who devote much time to the study of animal populations inevitably develop a thoroughgoing respect for the resilience of nearly all species in replacing losses, and for the vital part played in the yearly turnover by that upper deadline which marks the carrying capacity of the range. From what we have seen, it is logical to expect that shooting off half or more of the squirrels would result in greater proportionate production by the remaining breeders and better survival of young than if only a quarter of the animals were taken.

To illustrate the effect of hunting on squirrel numbers, two theoretical population curves are shown in fig. 128. Both start with 50 breeders under identical conditions except that in A the population is hunted and in B it is not. The curves show the approximate high and low points for the year and the periods during which numbers are being augmented and depleted. For this purpose a squirrel is not counted until it is out of the nest and beginning to care for itself. The year-to-year carrying capacity of the range is considered to have remained the same—that is, the population did not increase or decrease from one year to the next.

The main point illustrated by these curves is that there must be fewer animals lost to natural causes when a population is hunted than when it is not hunted. The best way to understand this is to set up constant theoretical conditions as we have here. If it is assumed that the range is stocked to the limit, and it will support the same number each year, then it is evident that every 12 months all squirrels produced over and above the breeding population must be lost to one cause or another. If hunters do not get them, they will be accounted for by other factors. The logical conclusion is that the sportsman can get a larger share of the annual squirrel mortality simply by shooting more, rather than by worrying too much about predators or other specific factors that may account for the yearly surplus. What the limitations to this thesis are remains to be seen, but it is doubtful that we would go very far wrong in giving it general application.

In these calculations we have been considering the maximum possibilities for a hunting crop. They imply intensive management and intensive utilization. Possibly the day will come when such close figuring will be necessary, but for the present it must be con-

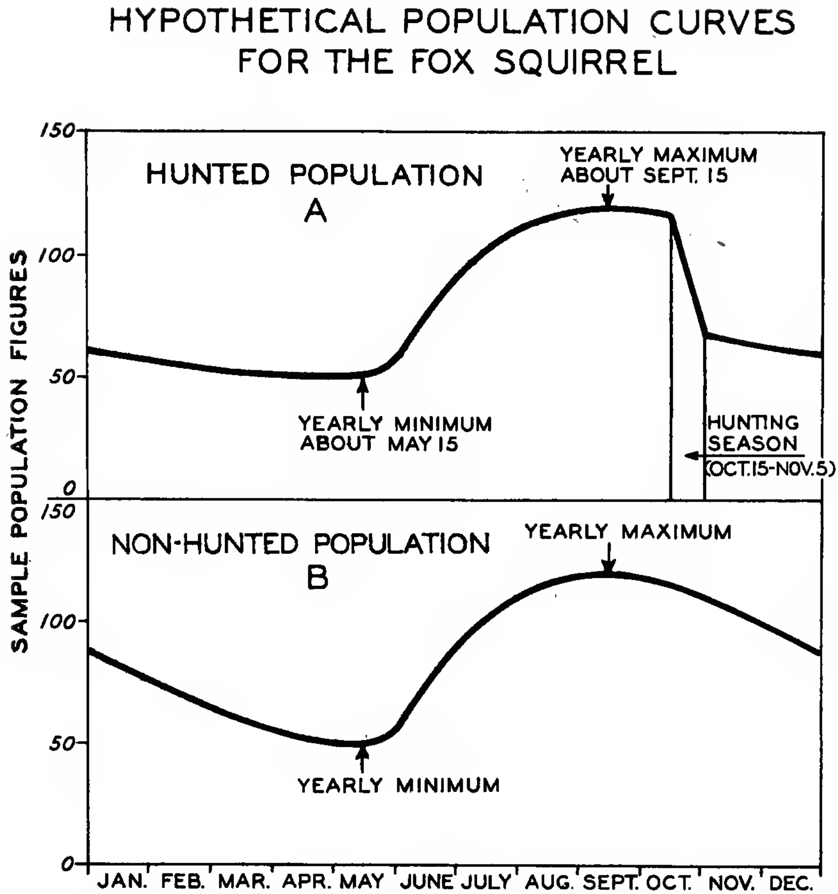


Fig. 128. These curves illustrate the approximate changes in number throughout a year in two fox squirrel populations under identical conditions except that one is hunted and one is not. The point of emphasis is that the ultimate losses in a population will be the same whether or not it is hunted. It must be understood that the word "loss" is used in the broad sense and can mean an old squirrel that dies, or a young squirrel that dies or is not born because an old animal survives in its place. The point marked "yearly minimum" in curve B would not necessarily be the same as in curve A as shown here, but by fall both populations should represent the carrying capacity of the habitat at approximately the same level. Observations indicate that the population curve of fox squirrels varies radically from one year to the next, but that fall numbers in most cases reflect range carrying capacity whether the number of breeders was large or small.

sidered instructive speculation. There are enough under-cropped and "closed to hunting" woodlands in the state so that there is little danger of the hunter getting too much.

REGULATIONS AND ENFORCEMENT PROBLEMS

In southern Michigan the 1942 hunting season on fox squirrels, gray squirrels, pheasants, and rabbits began on October 15. Pheasant and squirrel hunting stopped on November 5, and rabbit shooting continued until the end of December. Enforcement problems make it desirable to handle several species together in this way when such an arrangement reconciles readily with animal habits and the best interests of hunters.

The Open Season

Squirrels were first protected in Michigan in 1897.[29] By act 159 of that year the legislature made it unlawful to hunt gray, black, or fox squirrels except from October 1 to December 31. In this state there has never been an open season on game squirrels earlier than October 1.

Summer versus fall shooting

This is in contrast to other midwestern and southern states where it has been common for squirrel hunting to begin in July, August, or even earlier. Goodrum (45) found that there was an open season during a squirrel breeding period in all of the 47 counties surveyed by him in east Texas. Bennitt and Nagel (15) brought out an interesting point to account for the June 1 opening of the squirrel season in Missouri. Hunters in that state are primarily concerned with getting squirrels while they are young and tender. The half-grown young of the first litter, taken during June and July, are especially esteemed. Figures gathered by the authors cited indicate that female squirrels with second litters are less active and less likely to be shot during these months than males or first-litter young.

Despite the fact that circumstances may tend to mitigate the effect of shooting during a breeding and rearing season, there is no doubt that hunting in summer orphans many broods of young which would otherwise be brought through to fall. This happens in a few cases even in Michigan's fall shooting season. In 1941 a lactating female, doubtless with a dependent litter, was found on November 11.

[29]See page 29 for a historical summary of regulations.

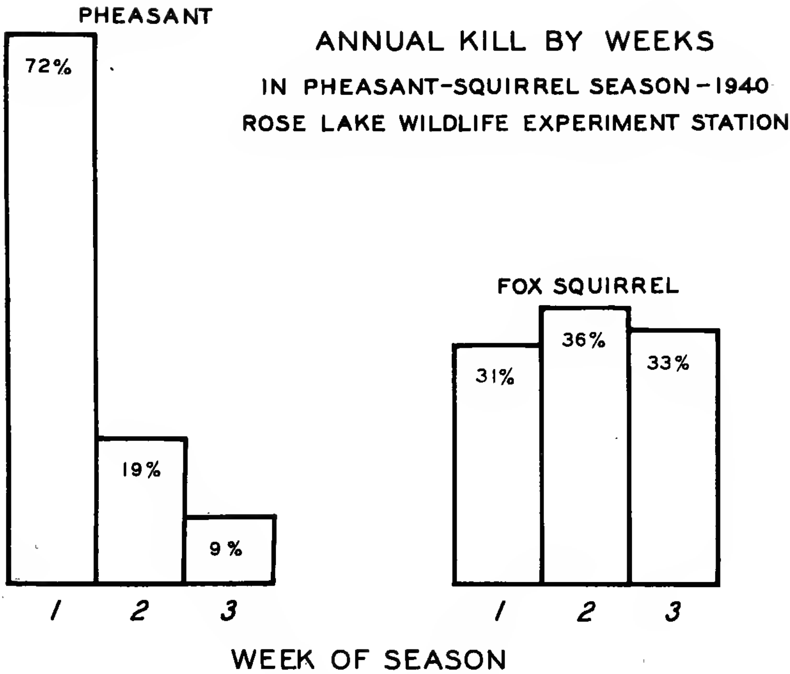


Fig. 129. Length of season is important to the fox squirrel because the percent of kill is fairly uniform through the season, and another week would mean many more squirrels taken. The addition of a week would mean few more pheasants since the kill declines rapidly after the first week. It cannot be assumed that the same measure will affect all species alike.

In areas where the meat value of the squirrel crop exceeds other values, summer shooting may be justified. In Michigan this problem does not complicate the situation. Fox and gray squirrels are considered by the public primarily as sporting animals, with the culinary angle distinctly subordinated. The few young squirrels sacrified by the shooting of females in the present open season are hardly worth considering.

Length of season

At the Rose Lake experiment station in 1940, squirrel populations and hunting appeared to be fairly representative of average conditions. Fig. 129 shows the percent of the kill by weeks during the season compared with that of the pheasant in the same period. It

has been evident in these studies that pheasants are cropped for the most part early in the season and that hunting of that species is subject to rapidly diminishing returns as the season advances.

This does not appear to be true of squirrel hunting. Owing to the competition of pheasants for the hunter's attention, squirrels do not have the heavy first-day hunting that the birds experience. Hunting is more uniform and the yield of squirrels also quite uniform, being maintained to the end of the shooting period. In the case of the pheasant, adding a week to the season would mean few more birds killed. This same measure applied to squirrels would raise the kill considerably.

There has been some consideration of an extension of the pheasant season to 30 days. There is no doubt that these birds could easily sustain another week of hunting. But until more is learned on the subject, it appears prudent to leave the squirrel season as it is. There are doubtless many areas where another week of squirrel hunting would not result in overshooting, but in others it might. It is apparent that, in the case of squirrels, regulating the length of the season is a good way to regulate the kill. And from the data now at hand, the 22-day season from October 15 to November 5 is of a satisfactory length, and it comes at the proper time.

Bag Limit

The Michigan bag limit on game squirrels is 5 per day, 10 in possession, and 25 for the season. This regulation is now the same as when the first bag limit for squirrels was declared in 1921. It applies to fox squirrels, grays, or both combined. The majority of hunters appear to be satisfied with this limit and for the present it probably should be left as it is. Eventually season limits probably will be discarded. They can not be enforced, and few hunters exceed them anyway.

Regulations on Gray and Black Squirrels

From 1911 to 1939 neither gray nor black squirrels were legal game in Michigan. But this species became plentiful in the northwest counties of the lower peninsula, and this region (see map, p. 64) was opened to the hunting of the gray phase in 1939.

During recent years gray squirrels have also "come back" conspicuously where extensive woodlands are developing on southern submarginal areas. In some regions, distinguishing between gray and fox squirrels became a problem to hunters and Conservation Officers. As a result of this situation, in 1941 the entire lower peninsula was opened to the hunting of both gray and fox squirrels, although this did not include the black phase of the gray. There is no apparent reason why this general open season should not be retained.

The question is now arising in some northern districts whether or not an open season on black squirrels is justified. There is no doubt that many blacks are shot each year, being mistaken for legal game. There are now many places where they are periodically abundant and where they outnumber the gray phase. In these areas this animal could support at least an occasional open season. But the distribution of such localities appears to be rather "spotty," and if hunting really was the factor which caused the rapid decline of the blacks (p. 28) in the last century, this might recur.

The black squirrel probably has no peer in esthetic value among Michigan mammals. It may be jet black, frosted or flecked with white, or washed with tawny. Or it may appear to be intermediate between black and gray. Always it is an animal of outstanding beauty and one which should be preserved by any means necessary. Continued favorable conditions may warrant an open season on both phases of the gray squirrel in some counties. It would not be surprising if such were entirely successful. This will need to be done experimentally and evaluated before we will know the "score" regarding our northern black squirrels.

Identification of Game Squirrels

When the entire lower peninsula was opened to gray squirrel (light phase only) shooting in 1941, Conservation Officers were relieved of the necessity for proving the identification of animals in cases of the illegal shooting of grays. Future trends in populations may again call for discrimination between fox and gray squirrels, and it will be well to point out the differences between them.

species. As to size, fox squirrels are larger, and they are less slim and rangy than the grays; but since there are juveniles to contend with, size will not help much. As shown in fig. 130, the profile of the gray is more rounded than that of the fox squirrel, and the ear is longer and more pointed. The ear is usually a good character and should help identify the gray or black at a glance. However, these also are quantitative characters and subject to individual variation as well as interpretation by the observer.

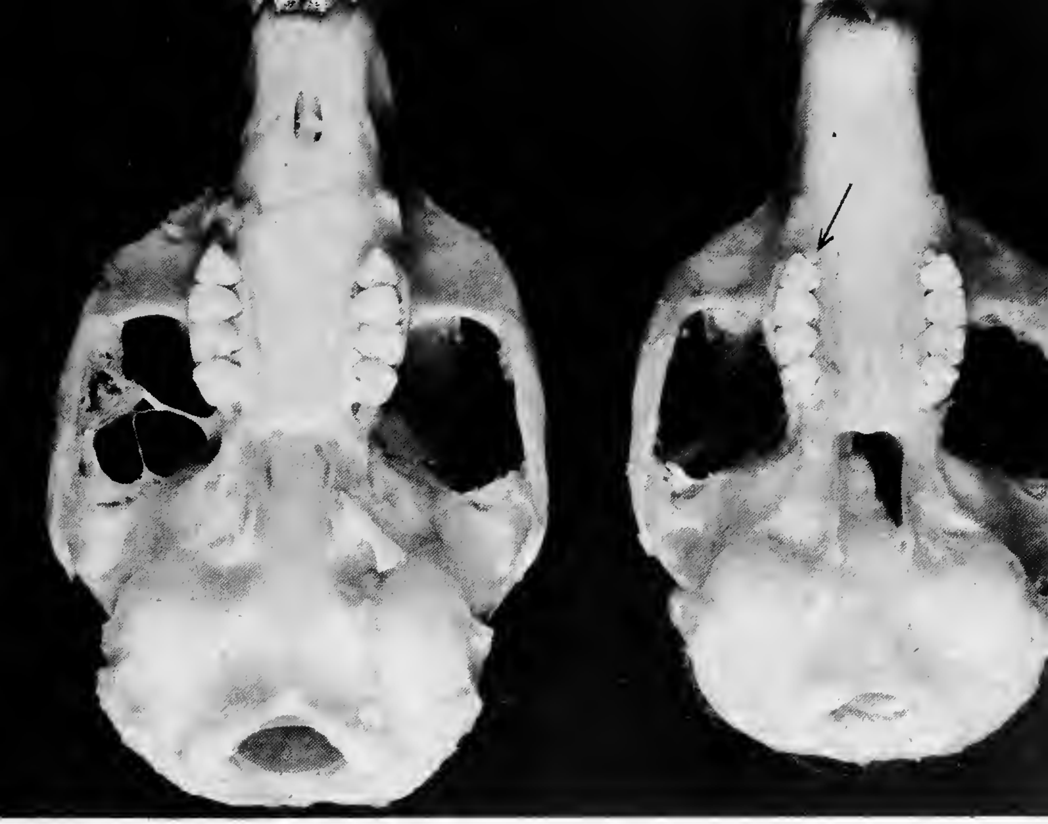
Perhaps the most constant gray squirrel character is the white tip of the long hairs of the tail. This has not been known to vary except in conspicuously aberrant specimens. In fox squirrels the tail guard hairs are tipped with variations of tawny or rusty orange. The white belly fur of the gray (not the black phase) in lower Michigan is also a good character. The belly fur of the fox squirrel is sometimes very light buff, but it would seldom be mistaken for the white of the gray squirrel. In the latter species the underfur is lead gray. In the upper peninsula gray squirrel, dark belly fur is nearly always in a definite pattern superimposed upon the white.

A certain identifying character for gray or black squirrels is the extra rudimentary tooth which is sometimes found close against the front functional molar (fig. 131). A weakness in this character is that some specimens lack the tooth. But it is always missing in the fox squirrel, so that an animal showing it can definitely be called a gray.

Several years ago a Conservation Officer who had hunted and eaten squirrels for many years pointed out to me a difference between these two species that is not generally known. The bones of the gray squirrel are white and the bones of the fox squirrel are definitely pink. I have tested this character by boiling the leg bones and by preserving them in formalin, and the pink color in the fox squirrel bones remains. It has not been widely used, but I believe the difference to be reliable for separating the two species. By an examination of the bones, tail hairs, belly fur, ears, and teeth, it should be possible for an experienced officer easily to identify 95 percent or more of the squirrels that are brought to him.

Squirrel "crosses"

Black and gray squirrels commonly interbreed (64). The genetics of coat color in the species are unknown; but since we are



L. C. Hulbert

Fig. 131. Gray squirrels typically have an extra rudimentary tooth lying close to the anterior molar (see arrow at right). In fox squirrels (left) this is never present. It would be an excellent identification character except that it is also absent in some gray squirrels.

dealing with one species, there is no reason for considering any gray squirrel, regardless of color, as a cross or hybrid.

No published record has been found of gray squirrels interbreeding with fox squirrels. From analogy it would not seem likely that two species differing so evidently in their physiology, habits, size, etc., would cross. It is true that one of the upper peninsula specimens already referred to in the University of Michigan museum might from its appearance be considered intermediate between the gray and fox squirrel. But it can safely be stated that practically all of the fox-gray crosses commonly reported in the newspapers are aberrant fox or gray squirrels of honest parentage.

Summary of Chapter Sixteen

A 22-caliber rifle is the ideal gun for squirrel hunting, although most Michigan hunters own and use shotguns. Good squirrel dogs also add interest and efficiency to hunting, but they are not in common use.

Fox squirrels are highly mobile during the hunting season and inclined to concentrate where food is plentiful. For this reason it is difficult to harvest the species on an acreage basis, and the overshooting of an individual woods will usually be neutralized in the general fall reshuffling of populations.

A hunting season crop of the proper size takes only squirrels which would otherwise be accounted for by other causes, and thus, up to a certain point, natural losses can be transferred to the hunter's bag merely by shooting more squirrels. Where this process stops and overshooting begins will need to be determined experimentally.

The present fall shooting season, from October 15 through November 5, is satisfactory, as are the present bag limits.

In contrast to some other species, the squirrel crop is taken fairly uniformly through the season, and hence lengthening or shortening the shooting period is an efficient way to increase or limit the kill.

Present regulations opening the entire lower peninsula to gray (but not black) squirrel shooting appear to be sound. Some northern counties probably should be opened experimentally to the shooting of black squirrels.

Under past conditions the difficulty in distinguishing fox and gray squirrels was an enforcement problem. These species are subject to great color variation, but nearly all specimens can easily be separated if the officer is well acquainted with their differences.

Conclusion

THE MANAGEMENT FORMULA

THESE THINGS are most important in Michigan for squirrel management:

First, there must be good range. Which means, above all else, consistency in the food supply. That and the other things a fox squirrel needs must be built into a pattern of woodlands intermixed with open land. The more mixture, the better, so that there will be many edge trees to fruit plentifully and produce large seed crops. Among these should be the mast-bearing kinds, oaks, hickories, walnut, and beech; and the more species there are, the more dependable the supply will be. Cornfields along the woods margin are further insurance against want. Within the timber stands there should be hollow trunks, where broods are safe and winter blizzards do not matter. These probably are the essentials of a good range.

When conditions favor, fox squirrels have an impressive capacity to reproduce and survive. They stock the range, nearly every year, to its full supporting capacity. In a succession of similar years, there should be seasonally similar numbers of squirrels. But each year has its ebb and its flow. Potentially, every April animal could be three by October. But by another April there must be only one again, and hence two are expendable. The hunting harvest is a part of the two-thirds which die. It is proper for the hunter to take a large share of this overproduction. He should kill 40 percent, or even more, of the fall population. Good range yields abundant game crops, and these should be intensively utilized. If the yearly harvest is not taken, surplus squirrels will be expended anyway. Whether reduction comes through malnutrition, scabies, exposure, accidents, enemies, or competition with the new generation, is unimportant. Within limits, the hunter can transfer such losses to the game bag merely by taking more.

A favorable environment and heavy hunting should mean healthy squirrels, productive breeding, and high survival. If mast is plentiful, each animal can feed well and lard his paunch with half a pound of fat. By combined efforts of the population an immense store of nuts is buried in the ground. Then the hunter shoots many squirrels. Those left over have the food stored by all and are housed in the best tree dens. Through periods of storm, when two

feet of crusted snow seal in the food supply, they roll up in lined hollows and live on the extra meals of autumn. When times improve, they come out to breed and forage. In the thinned-out population disease is lessened, as well as competition between breeding adults, and between adults and young. If in June the range is still understocked, perhaps more summer litters will make up for it. Habitat conditions count much more than numbers of breeders.

There are many details we do not have. Some of our most significant points need further proving. But in general the picture has been roughed in. Food and belly fat, shooting and living space, tree dens and protection, healthy squirrels and many litters—that, it seems, is the formula.

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Appendix

APPENDIX A

Statements from squirrel questionnaires (1941. See p. 14) regarding the presence of fox squirrels in the southwestern prairie region of Michigan at the time of settlement (p. 31). Counties are listed from south to north.

Berrien County

Charles L. Miller, St. Joseph—Mr. Miller's uncle was an old squirrel hunter in Berrien County more than 75 years (1865) ago, and fox squirrels were very plentiful at that time.

Cass County

Arthur Goodrich, Dowagiac—Fox squirrels were present in Cass County in 1840. People questioned by Mr. Goodrich believed them to be native.

B. A. Herold, Dowagiac—"As far as I can learn, Cass County has always had fox squirrels."

W. A. Stolley, Dowagiac—"I located in this part of the state in 1885. This part of Michigan has always been inhabited by the fox, black, gray and red squirrels."

St. Joseph County

Edward W. Fish, Three Rivers—"Can find no one that can remember when there were no fox squirrels in this county. Apparently they have been here longer than the older residents, and in fairly good numbers."

Clayon Conrad, Three Rivers—"Fox squirrels have been common here from the time this county was settled."

Van Buren County

M. E. Weston, Paw Paw—Fox squirrels present and plentiful "as far back as I ever heard of."

Edward Soergel, South Haven—Mr. Soergel's father, who was a market hunter, says blacks and grays were most plentiful in 1880. After the walnut and white pine were cut, these squirrels declined and the fox squirrel increased.

Frank Hazzard, Decatur—Arthur Bishop of Decatur states that fox squirrels were first seen in 1890 and have been plentiful since then.

Kalamazoo County

Frank R. Snow, Kalamazoo—States that fox squirrels have been present 60 years (1880) and long before.

APPENDIX B

Statements from squirrel questionnaires and letters relative to the spread of the fox squirrel from the southern counties north and eastward after the breaking up of the hardwood forests (see p. 35).

Lenawee County

R. L. Olmstead, Adrian—"Fox squirrels were here at least 100 years ago, as Tom Munger, Adrian, remembers an old man who died many years ago say that he shot them when he was a boy."

Monroe County

Bruce Lavender, Monroe—"Have checked old hunters, and they say we have always had fox squirrels—ages of men 78, 82, 56."

Washtenaw County

Frank W. Denner, Kalamazoo—"I was born in Lodi Township, Washtenaw County in 1868, and my early recollection of squirrels was when my father went hunting and came home with only gray and black. I was, no doubt, about 5 or 6 years old, which would be about 1873 or 74. I started to hunt as soon as I was able to carry a gun, which would make me about 12 or 14 years old, or about 1880. Sometime between 1874 and 1880 the gray and black squirrels left and the fox squirrel came in, as I killed plenty of fox squirrels but never killed a gray or black, nor do I remember of seeing one at that time."

Calhoun County

James B. Brown, Marshall—"My father and grandfather have told me of the old days when there were only gray and black squirrels . . . " Mr. Brown says that fox squirrels were first seen in the county previous to 1880.

Allegan County

A. L. Larson, Wayland—According to Charles Ward, Wayland, fox squirrels were first seen in the county about 1880.

Barry County

Homer L. Smith, Hastings—Wm. D. Bennett, Hastings, stated that fox squirrels were first seen about 1872.

Livingston County

Cleve Copeland, Fowlerville—"My grandfather settled in this country over 100 years ago, and I have heard my father tell of shooting fox squirrels in great numbers as well as gray and black."

Genesee County

James R. Campbell, Flint—Fox squirrels appeared in the county about 1886.

William Reed, Flushing—Frank Fuller, Flushing, stated that fox squirrels have been in the county as long as the oldest residents can remember.

Shiawassee County

M. F. Blair, Owosso—Fox squirrels were first seen in the county about 1870.

Ionia County

D. K. Jepson, Ionia—According to Herbert Smith and Eldly Man, fox squirrels first appeared about 1850.

Kent County

M. H. Noble, Grand Rapids—Fox squirrels first seen about 1878 according to C. B. Corbin, Grand Rapids.

Charles A. Roberts, Kent City—Fox squirrels have been in the region for at least 60 years, since 1880.

Muskegon County

P. A. Elliott, M. D. Elliott—James L. Smith says that fox squirrels have been in the county for 70 years (1870).

Vincent Eilers, Montague—Mr. Eilers' father first saw fox squirrels about 1898. He first settled in the county in 1875.

G. B. Skipper, Muskegon—Frank Weber and Ross Ferguson of near Muskegon say the fox squirrel first appeared in the region about 1850.

Newaygo County

Stanley Boutin, Fremont—According to Riley Tindall and Cliff Raeder, of Fremont, the first fox squirrels were seen about 1900.

Montcalm County

J. M. Irish, Greenville—C. B. Rarden and Charles Van Hoose state that fox squirrels appeared in Montcalm County about 1887.

Gratiot County

J. L. Bennett, Alma—Fox squirrels were coming into this county in about 1895.

Tuscola County

C. A. Stewart, Caro—The first fox squirrels were seen in about 1870.

Huron County

A. J. Neering, Pigeon—Claude Dufty, Caseville, reported that there were no fox squirrels in the county until about 1915.

Gordon Moffitt, Bad Axe—According to Howard Rodgers, Port Austin, fox squirrels appeared about 1908.

Bay County

A. B. Asman, Bay City—John Cotter, Essexville, says fox squirrels have been in the county since 1876.

Midland County

Floyd Nagle, Jr., Midland—Fox squirrels have been in the county more than 50 years (1890).

Isabella County

W. B. Tennant, Mt. Pleasant—Fox squirrels known to have been there for at least 60 years (1880).

Mecosta County

Byron Aldrich, Big Rapids—First seen about 1890 by H. J. Langworthy, who came to the area in 1875.

Mason County

B. N. Betka, Ludington—These squirrels first seen in 1892 by Frank Hirner, Ludington.

Lake County

H. W. Fulton, Luther—William Burnett, of Luther, says they appeared 1895-1900. Floyd Gray (Luther) states that the fox squirrel was in the county previous to 1895.

L. A. Dorman, Baldwin—Opinion expressed by Ross Gleason, William Duffing, Harry Duffing, and Byers Cashien of Baldwin that the fox squirrel appeared in the county about 1900.

Clare County

T. G. Bowler, Clare—Various old residents state that the fox squirrel first appeared in the region about 1905-10.

F. T. Bush, Harrison—Joseph Ladd, Harrison, a resident of the county for 61 years, says fox squirrels appeared in 1916.

Iosco County

F. E. Kunze, East Tawas—Mr. and Mrs. J. G. Dimmick of East Tawas say that the first fox squirrels were seen about 1902. John North recalls seeing them in 1870 when he was a boy in Tawas Township. In 1882 a fire swept through the area, and they disappeared.

A. G. Leitz, East Tawas—Harry Cross of East Tawas reports that fox squirrels were appearing in the county in 1905.

Otto DeWaard, Oscoda—Sam Gardner, of Oscoda, says the first fox squirrels were seen in 1896.

Ogemaw County

J. W. Baird, West Branch—M. A. Jackson says they appeared about 1920.

Missaukee County

R. W. Gilliom, McBain—Vern Gray, of McBain, says there were fox squirrels in the county in 1870.

Manistee County

R. R. Wolters, Manistee—According to Frank Schneider, Clyde Hawkins, and A. L. Showalter, of Manistee, fox squirrels first appeared about 1902.

Grand Traverse County

Mark Craw, Traverse City—"I can remember seeing fox squirrels (never plentiful) thirty or forty years ago. I have a photograph of a mixed bag of small game including one fox squirrel taken about 1899 or 1900."

Crawford County

C. L. Crandall, Frederic—"I put in several hours talking with old timers in the north part of Crawford County to get information to complete questionnaire. As to what year fox squirrels first appeared, I got answers from 1890 to 1915."

Otto Failing, Grayling—Fox squirrels appeared about 1912.

E. L. Madsen, Grayling—Fox squirrels first seen about 1910 according to A. C. Wakeley, Grayling.

Oscoda County

W. R. Stark, Mio—Fox squirrels appeared about 1925.

Verne Dockham, Mio—According to Abner Hoy, of Mio, and John Winton, of Fairview, the fox squirrel was first seen about 1921 (see p. 37).

Alpena County

William Connors, Alpena—F. A. Morey, of Alpena, says the fox squirrel first appeared about 1925.

Montmorency County

Waldo Whitehead, Atlanta—According to Frank N. Smith, fox squirrels were first seen in Montmorency County in about 1900.

W. J. Cronk, Hillman—Fred and Dave Hubert, of Hillman, say that the first fox squirrels appeared in this area in 1921.

Antrim County

J. F. Bugai, East Jordan—Older residents say there have been a few fox squirrels in the northern half of Antrim and the south half of Charlevoix Counties for 75 years (1865) but they did not become numerous until 20 to 25 years ago.

C. D. Kaufman, Bellaire—Fox squirrels first appeared about 1918.

L. L. Miles, Bellaire—Fox squirrels came into the county about 1920.

Leelanau County

Elmer Billman, Cedar—Fox squirrels have been in the county since 1895.

Cheboygan County

Frank Banks, Wolverine—Fox squirrels came in about 20 years (1920) after the big timber was cut.

Norman Auldrich, Cheboygan—Hobert Kirsch, of Cheboygan, says fox squirrels first seen about 1925.

Charlevoix County

E. A. Deuell, Boyne City—Fox squirrel first seen in 1920.

Emmet County

Thomas Koboski, Petoskey—A very few fox squirrels appeared in the county about 1930.

APPENDIX C

Statements and information from squirrel questionnaires on present (1941) and past numbers of black and gray squirrels in the various counties. Fox squirrel notes are given for the northern counties. The latter species has been reported plentiful in practically all parts of southern Michigan. The counties are listed from south to north.

Berrien County

Gerald Cline, Benton Harbor—Gray squirrels are scarce and blacks very rare.

Cass County

Don Miller, Dowagiac—There are a few grays but no blacks.
B. A. Herold, Dowagiac—A few grays and blacks, about 4 to 1, respectively.

W. A. Stolley, Dowagiac—Has seen a scattering of gray squirrels but only one black.

L. Gates, Dowagiac—An occasional gray squirrel seen.

Thomas Shelhamer, Dowagiac—"I do not think that more than 1 or 2 percent of the squirrels here are grays, and no blacks have come to my notice. All grays seen here have been in low or swampy woodland . . . "

F. J. Riley, Marcellus—Has not seen a black squirrel and but few grays.

St. Joseph County

E. W. Fish, Three Rivers—Black and gray squirrels gone for the past 50-60 years.

Clayton Conrad, Three Rivers—No gray or black squirrels.

Branch County

C. G. Cole, Coldwater—No gray or black squirrels.

Hillsdale County

C. B. Reason, Hillsdale—No grays or blacks.

Monroe County

Bruce Lavender, Monroe—No gray or black squirrels. They were gone with the big timber.

Wayne County

C. A. Lorenzo, Detroit—A very few gray and black squirrels, about 9 to 1.

B. E. Champe, Plymouth—A few grays.

Washtenaw County

A. D. Mayer, Chelsea—A few gray squirrels.

Fred Earle, Ypsilanti—A few grays.

Jackson County

W. T. LeMieux, Jackson—No grays or blacks.

Calhoun County

W. J. Taffee, Battle Creek—Grays and blacks few.

J. B. Brown, Marshall—No blacks outside of cities and few grays.

Kalamazoo County

F. R. Snow, Kalamazoo—Only one black squirrel record.

B. G. Goslin, Augusta—A few gray and black squirrels.

Addison Reed, Richland—A very few grays and blacks.

V. D. Winey, Kalamazoo—Last blacks seen in 1894-95 according to E. E. Cavanaugh, Kalamazoo.

C. M. Waddle, Kalamazoo—A very few gray and black squirrels.

Van Buren County

Frank Hazzard, Decatur—No grays or blacks.

Edward Soergel, South Haven—Mr. Soergel's father was a market hunter and stated that blacks and grays were most plentiful in 1880. After the walnut and pine were cut, these squirrels declined and the fox squirrel increased.

M. E. Weston, Paw Paw—Few grays and probably no blacks.

George Taack, Paw Paw—"There are neither gray nor black squirrels in Van Buren County."

Allegan County

A. L. Larson, Wayland—A few grays and blacks.

Barry County

George Summer, Hastings—Gray squirrels scarce and less blacks.

H. L. Smith, Hastings—Only a few grays.

Eaton County

L. F. Baldwin, Eaton Rapids—Gray squirrels few, no blacks.

D. J. Benjamin, R. 1, Lansing—No gray or black squirrels.

Ingham County

E. V. Blohm, Mason—Scattered grays in heaviest timber; no blacks seen or reported.

Livingston County

Cleve Copeland, Fowlerville—Grays and blacks very scarce. Those present are nearly all grays.

Oakland County

Charles Baker, Fenton—Grays not plentiful but increasing. Has not seen a black squirrel in 30 years.

St. Clair County

Blue Water Sportsman's Association—A gray or black occasionally seen.

T. J. Wreath, Marine City—No blacks or grays.

Genesee County

W. A. Prendergast, Flint—A few grays in county.

Harvey Swanebeck, Fenton—Grays and blacks not plentiful. About 95 percent of those present are grays.

A. G. Abraham, Flint—Grays few and blacks even less numerous.

O. A. Mitchell, Flint—No grays seen in 31 years.

J. J. Crosby, Flint—Has not heard of gray or black squirrels for 25 years.

J. R. Campbell, Flint—A few grays reported east of Montrose.

William McCumsey, Clio—A few grays but blacks all gone.

Shiawassee County

M. F. Blair, Owosso—No gray or black squirrels.

F. C. Bishop, Owosso—A few gray squirrels in northern part of the county.

Clinton County

R. A. Myers, St. Johns—No gray squirrels in county.

Ionia County

L. D. Kahl, Ionia—No gray or black squirrels.

D. K. Jepson, Ionia—No grays or blacks.

Kent County

Roy Buzzard, Kent City—A few grays and less blacks.

John A. Kroll, Grand Rapids—No grays and a few blacks.

M. H. Noble, Grand Rapids—Very few gray and black squirrels.

Frank Carle, Grand Rapids—A very few grays and blacks.

Charles A. Roberts, Kent City—Grays and blacks scarce, about 3 to 1, respectively.

Ottawa County

J. N. Lievense, Holland—Grays and blacks present but not numerous, mostly the former.

Forrest Lavoy, Holland—Gray and black squirrels not numerous, about 1 gray to 3 blacks.

Muskegon County

G. B. Skipper, Muskegon—Gray and black squirrels became very scarce some 40 years ago, and all three (including fox squirrel) have been getting more plentiful ever since. They are plentiful now, and grays furnish good hunting. About 60 percent grays and 40 percent blacks.

Vincent Eilers, Montague—Grays are plentiful but not blacks; about 70 percent gray and 30 percent black. Fox squirrels numerous.

P. A. Elliott, M. D. Elliott, Muskegon—A few grays and blacks. Fox squirrels plentiful.

Montcalm County

J. D. Hammar, Stanton—Fox squirrels plentiful. Grays and blacks numerous in some areas, particularly in western portion. About 40 percent grays and 60 percent blacks. "For some years after the virgin timber was cut there were few squirrels in this part of the country, but as a good crop of second growth came on the squirrels multiplied. They are mostly fox squirrels, but in portions of the county the grays and blacks far outnumber the fox squirrels."

J. M. Irish, Greenville—Fox squirrels plentiful and good hunting. A very few grays and blacks reappeared about 1922.

Gratiot County

J. L. Bennett—First noted fox squirrels in this county about 1895. They furnish good hunting now. A very few blacks present also.

Tuscola County

K. W. Black, Unionville—Fox squirrels present but poor hunting. No grays or blacks.

C. A. Stewart, Caro—Fox squirrels plentiful and first seen about 1870. No grays or blacks.

Huron County

Gordon Moffitt, Bad Axe—No grays or blacks seen for 35 years.

Bay County

A. B. Asman, Bay City—There are a few grays, but black squirrels have been absent for over 30 years.

E. W. Wheeler, Bay City—There are a few fox squirrels, although not enough to furnish good hunting. No grays or blacks.

Midland County

Donald McBeath, Midland—Fox squirrels plentiful; gray squirrels few and found around cities.

Isabella County

W. B. Tennant, Mt. Pleasant—Fox squirrels plentiful. Few grays or blacks for last 25 years, although they were plentiful before.

G. R. Wheeler, Mt. Pleasant—Fox squirrels plentiful. Mr. Wheeler's father came to county in 1880 and there were only red squirrels present then. About 15 years later fox and black squirrels began to come in and the fox squirrel has been nnmerous ever since.

Mecosta County

Byron Aldrich, Big Rapids—Fox squirrels plentiful and furnish good hunting. Gray squirrels less numerous; about 75 percent gray and 25 percent black. "Since the second-growth oak got large enough to grow acorns . . . . the squirrels have spread all over the oak covered areas and have increased. Years ago they lived almost entirely in hardwood areas and in hollow trees near farms."

Newaygo County

Stanley Boutin, Fremont—Fox squirrels are plentiful. "Most people think grays plentiful enough to hunt, but not blacks. Both have decreased in last 50 years." About 80 percent grays and 20 percent blacks.

Newaygo County (Cont.)

C. O. White, Fremont—Fox squirrels are plentiful and good hunting. Grays are numerous enough for good hunting but blacks are not. About 80 percent gray phase and 20 percent black.

Alger Cline, White Cloud—Fox squirrels plentiful; also grays and blacks which should have an open season. About 60 percent gray and 40 percent black.

Oceana County

G. E. Rowley, Shelby—Fox and gray squirrels plentiful but not blacks. "More grays and blacks along the shore of Lake Michigan than there are further inland. They seem to be more plentiful in the big timber, while we find mostly fox squirrels in the oak grubs."

Mason County

B. N. Betka, Ludington—Fox squirrels numerous and first seen in 1892 according to Frank Hirner, Ludington. Gray squirrels plentiful and increasing. Grays and blacks about 5 to 1.

Ivan Roberts, Custer—Fox and gray squirrels plentiful and good hunting. Grays have increased during the past 15 years to equal the fox squirrels in number. Probably due to the growth of timber and fewer fires. About 75 percent gray and 25 percent black.

Lake County

F. I. Bradford, Baldwin—About 25 percent of the squirrels are grays and blacks, which were scarce up until 3 years ago. They have increased since that time. Fox squirrels are plentiful and good hunting.

F. C. Coles, Luther—Gray and black squirrels have been increasing. There were more fox squirrels 40 years ago—poor hunting.

D. B. Snyder, Baldwin—Fox and gray squirrels are about equal in numbers and both plentiful. About two-thirds of the gray squirrels are of the black phase. Squirrels have been increasing for the past 30 years.

J. W. Bull, Luther—Fox squirrels poor hunting. There are a few grays and no blacks.

L. A. Dorman, Baldwin—Fox squirrels plentiful and good hunting. According to several people interviewed, they appeared about 1900 (Ross Gleason, Baldwin; William Duffing, Baldwin; Byers Cashien, Baldwin; Harry Duffing, Baldwin). Grays and blacks are about 30 percent and fox squirrels about 70 percent of those present. Grays and blacks about 3 to 1, respectively. "Grays can probably be hunted without harm, but blacks are still scarce."

Lake County (Cont.)

H. W. Fulton, Luther—Fox squirrels plentiful and good shooting. According to William Burnett, of Luther, they appeared about 1895-1900. Floyd Gray, of Luther, says the fox squirrel was here previous to 1895. Gray and black squirrels are about as numerous as fox squirrels. There are about 3 blacks to 1 gray.

James Lee, Baldwin—Fox squirrels are plentiful. Grays and blacks (about 3 to 1) much fewer in number.

Osceola County

W. C. Kidder, Tustin—Fox squirrels plentiful. Grays and blacks were not seen for many years until about 5 years ago. About 2 percent of the squirrels are grays and blacks and they are about equal in number.

Clare County

T. G. Bowler, Clare—Doubtful if there are enough fox squirrels for good hunting. Grays and blacks (mostly grays) not numerous.

F. T. Bush, Harrison—Fox squirrels are now plentiful. Some grays and blacks (60% gray, 40% black) and blacks are increasing.

Gladwin County

Alfred McLain, Gladwin—After the cutting of the hardwoods, blacks and grays practically disappeared. With the regrowth of timber, the fox squirrel came in, and the blacks have also increased, but the grays are still behind in numbers. Fox squirrel furnishes fair hunting.

Arenac County

Donald McBeath, Game Division—A few grays and blacks about equal in numbers.

Iosco County

Otto DeWaard, Oscoda—Fox squirrels are not plentiful now. There are a few black squirrels but no grays.

F. E. Kunze, East Tawas—Fox squirrels present but not plentiful. Some blacks have been seen but no grays.

A. G. Leitz, East Tawas—Fox squirrels good hunting. Blacks and grays (4 to 1) about as numerous as fox squirrels.

Ogemaw County

H. B. Tubbs, St. Helen—According to John Regan and John Finnerty, of West Branch, fox squirrels appeared in the county about 1914. Black squirrels were plentiful until around 1900. They then practically dis-

Ogemaw County (Cont.)

appeared until about 1912 when they began to increase again. Probably 95 percent of the gray squirrels are of the black phase. None of the game squirrels is plentiful enough now for good hunting.

J. W. Baird, West Branch—Fox squirrels furnish fair shooting in the county. They appeared about 1920 according to M. A. Jackson. There are some blacks but no grays. Blacks have increased in the past 10 years. There have been two winters with poor mast supplies.

B. L. Foresman, Alger—Fox squirrels furnish fair hunting. There are a few blacks which have increased in the last 10 years. No grays.

Roscommon County

Thomas White, Houghton Lake—Fox squirrels furnish fair shooting. They first appeared about 1920. Grays and blacks are about one-fourth as plentiful as fox squirrels and only about 2 percent of them are gray.

G. J. Luhrs, Roscommon—Fox squirrels present but poor hunting—have been increasing. Grays and blacks not plentiful and about 1 to 4, respectively.

Missaukee County

R. W. Gilliom, McBain—Fox squirrels not plentiful. A very few grays and blacks, nearly all blacks. In the past 4 or 5 years, these squirrels have reappeared on the plains.

Wexford County

C. T. Johnson, Cadillac—Fox squirrels plentiful. Grays and blacks scarce and equal in numbers.

Orville Rettig, Cadillac—Fox and grays plentiful enough for good hunting. Grays and blacks about 4 to 1, respectively.

Manistee County

R. R. Wolters, Manistee—All squirrels plentiful. Grays and blacks approximately equal in numbers. "We lost a number of squirrels in 1928 and 1936 during the winters of cold weather and very deep snow. A good many skeletons found in the following springs."

Benzie County

B. P. Griffiths, Honor—Fair fox squirrel shooting. First seen 1888 according to Adam Brown, of Honor. Grays and blacks are about equal in number and not plentiful enough to hunt. Squirrels are on the increase due to regrowth of timber.

Benzie County (Cont.)

Rex Joslin, Honor—All squirrels plentiful. Fox squirrels in all parts of the county. Grays and blacks (equal in numbers) most numerous along Lake Michigan. "About 45 years ago I saw the last gray squirrel. Did not see another until about 1925. Since then they have increased rapidly. Blacks about the same here."

Grand Traverse

Mark Craw, Traverse City—Fox squirrels plentiful and good hunting. Grays and blacks less numerous and about equal in numbers.

I. H. Garthe, Traverse City—A few fox, gray, and black squirrels. Not enough squirrels to create much interest.

Kalkaska County

C. L. Hicking, Kalkaska—Fox squirrels plentiful and good hunting. A few gray squirrels.

Crawford County

Harry Souders, Grayling—Fox, gray, and black squirrels all present but not plentiful enough for good hunting. Many more blacks than grays.

E. L. Madsen, Grayling—Fox squirrels plentiful. Grays not plentiful enough to furnish good hunting. Squirrels have increased since cutover land came up to oaks and these matured. Gray-black ratio about 5:95 respectively. "I don't think that the squirrel will ever be an important game animal in this area because of the uncertainty of the acorn crop."

C. L. Crandall, Frederic—Fox squirrels plentiful. Grays are not numerous enough for good hunting, though slightly more common than blacks. There was a time about 1900 when black squirrels were much more abundant than any time since.

Oscoda County

W. R. Stark, Mio—All squirrels present but hunting poor. "The grays and blacks have become quite numerous and the fox squirrel is still scarce. Black squirrels could stand more shooting than the gray or fox in this county, although there are 2 or 3 sections that have quite a number of fox squirrels. Shooting them in those areas would perhaps be all right."

Verne Dockham, Mio—Fox squirrels not plentiful. Grays and blacks same. About 30 percent gray and 70 percent black. (See quotations in text p. 37).

Alcona County

Donald Gillies, Lincoln—No game squirrels plentiful enough for good hunting. Fox squirrels more common than gray (20%) and black (80%). According to old timers there was a still higher percentage of blacks 40 years ago.

Alpena County

William Connors, Alpena—Grays and blacks (3 to 1 respectively) have never been plentiful and are very scarce now. "Squirrels live in oak timber in this county. Old timers say that formerly there were no gray, black, or fox squirrels. In about 1925 oak began to get large enough in the open areas to furnish food, and squirrels began to appear. They are getting more plentiful each year and are now in all the oak timber. In some places all three kinds, although the fox squirrels are much the most plentiful. Some fox squirrels in the jack and Norway pine areas."

Montmorency County

W. J. Cronk, Hillman—Fox squirrels present but not plentiful enough for good hunting. Grays have increased but are not plentiful. About 3 grays to 1 black. Grays and blacks much more plentiful than fox squirrels.

Waldo Whitehead, Atlanta—Fox squirrels present but not plentiful. All of the squirrels disappeared in 1920 and reappeared again in 1931-32.

Otsego County

L. J. Marlatt, Gaylord—Fox squirrels present but not numerous. Also grays and blacks. About 70 percent of the squirrels are fox. Grays and blacks about 1 to 4, respectively.

Antrim County

J. F. Bugai, East Jordan—Fox squirrels plentiful enough to furnish good shooting—grays too. Blacks and grays outnumbered fox squirrel until about 30 years ago. About 10 fox to one gray or black now. Grays and blacks about 1 to 4, respectively. Fox squirrels favor cultivated areas and high dry forests.

C. D. Kaufman, Bellaire—Fox squirrels fair shooting now. Much more plentiful than gray (5%) or black (95%).

D. C. Kelley, Elk Rapids—According to Frank Duverny there are a few fox squirrels in the county and a few grays and blacks. None plentiful enough for good hunting. Grays and blacks about 1 to 10, respectively.

Leelanau County

John Bidleman, Empire—Fox squirrels furnish fair shooting. Grays and blacks more plentiful. Squirrel numbers about equally divided among the three.

Elmer Billman, Cedar—Fox squirrels plentiful and good hunting. Grays and blacks were more plentiful 40 years ago. About equally numerous now—gray, black, and fox. All are increasing.

Charlevoix County

E. A. Deuell, Boyne City—Fox squirrel first seen about 1920. Not plentiful and little hunting. "There are years when the fox squirrels are very abundant. It seems to depend on the crop of beechnuts." A very few grays and blacks.

Emmet County

Thomas Koboski, Petoskey—A very few fox squirrels in county. Grays and blacks fluctuate with the mast crop. Grays and blacks about 3 to 1, respectively. Only about 1 percent of the squirrels are fox.

Albert Gruler, Petoskey—No squirrels plentiful enough for good hunting. There are very few fox squirrels (1%) and more grays and blacks (99%). Grays and blacks (about equal in number) have increased during the past 30 years. Very little oak timber in this area.

Cheboygan County

Frank Banks, Wolverine—A few fox squirrels in county. More plentiful than grays and blacks. Grays and blacks (1 to 10) are increasing in this county since the hardwood timber is getting large enough to furnish food for them.

Norman Auldrich, Cheboygan—Squirrels very spotty in county. About 75 percent are grays and blacks and 25 percent fox squirrels. Grays and blacks now about 60:40, respectively.

Presque Isle County

John Adair, Onaway—Fox squirrels present but not numerous. Also blacks and grays. "I have been in this area more or less since 1893, and am convinced the cutting of the hardwood forest destroyed their natural habitat. Also forest fires have been a factor . . . " Blacks were formerly much more plentiful. Gray and fox squirrels are increasing.

Upper Peninsula

Mackinac County

Alex McLean, Engadine—No fox squirrels. Has seen only 10 gray squirrels in west half of county in last three years. No blacks.
J. H. Speck, St. Ignace—No fox squirrels; grays and blacks very rare.

Chippewa County

Roosevelt Haken, De Tour—No fox squirrels and only rarely a black.

F. W. Nelson, Brimley—No fox, gray, or black squirrels seen or reported in northeastern portion of county in past 30 years.

Joseph Hill, Pickford—Only one black squirrel seen in 18 years. A few grays and they are increasing.

Luce County

Frank Generou, McMillan—No fox squirrels. The few grays and blacks are increasing slowly. Grays more plentiful than blacks.

R. W. Beach, Newberry—A very few gray and black squirrels in the county which do not increase.

Schoolcraft County

Blaine Brannon, Shingleton—No fox squirrels. Have seen 3 grays in the past 5 years.

H. R. Peters, Germfask—Some grays and blacks. See an average of about one of each a year.

T. J. Mellon, Manistique—"To my knowledge we have no black or fox squirrels in this area, and the gray squirrels are very few in numbers and scattered . . . At one time about ten years ago we had considerably more grays than now, but it seems they are on the way out."

B. C. Furst, Seney—No fox squirrels. Grays and blacks are very scarce. They are found in woodlots around farming country where corn is raised.

Alger County

Julius Thorson, Munising—No gray, black, or fox squirrels.

Glen Price, Chatham—A very few grays have been seen in this county during the past several years.

Marquette County

Clyde Lambert, Big Bay—One report of a fox squirrel taken by a hunter in 1937. Has seen 12 gray squirrels since July 1939.

Edward Morris, Republic—No fox or other game squirrels in west half of county.

Emil Heikkila, Negaunee—No fox squirrels. A few grays which are increasing.

Ansel Christopherson, Gwinn—No fox or gray squirrels.

Jack Bowman, Marquette—No fox squirrels and only a very few grays.

Menominee County

D. H. Campbell, Wilson—A few grays but no fox squirrels.

Dickinson County

E. C. Ruecker, Felch—No fox or gray squirrels.

John Andrews, Iron Mountain—No fox squirrels known to have been in county. A few gray squirrels (possibly 5 percent blacks) for the past few years and they are increasing.

Iron County

I. C. Brown, Crystal Falls—No fox or black squirrels. A very few grays.

P. J. Houlmont, Alpha—No fox or black squirrels. A very few grays.

Baraga County

P. V. Challancin, Baraga—No fox squirrels and just a few grays.

S. D. Robinson, L'Anse—No fox or gray squirrels.

Houghton County

O. W. Sundquist, Houghton—No fox squirrels around Houghton. Gray squirrels are very rare.

Richard Lahti, Calumet—No fox, gray or black squirrels in this territory.

Ontonagon County

Archie MacDonald, Ontonagon—Has seen only 4 gray squirrels in the county in past 15 years.

Richard Lahti, Calumet—Saw two gray squirrels in this county in 1938.

Gogebic County

Leonard Bloomquist, Watersmeet—No fox, no black squirrels. A few grays.

Herman Strough, Marenisco—No fox squirrels, and grays and blacks are very rare.

John Chriske, Ironwood—No gray, black, or fox squirrels.

APPENDIX D

Range Maps Based upon Box Trapping and Hunting Records

Conclusions on the fox squirrel's range habits have been based upon records such as those given in the following pages. These maps show the location at which individual squirrels were taken at different times during their known history. Such ranges are necessarily incomplete and dependent upon the location of the traps used to catch the animals. In order that possibilities can be estimated, the locations of traps that did not catch a particular squirrel are also given on each map. The discussion with each figure outlines what is known of the breeding history of the individual in question and points out some of the more important movements that it made. All of these things must be considered in judging the amount of land area used by a squirrel, since its habits are seasonal and to some extent dependent upon the age of the individual, weather, and other environmental variables. (See discussions on p. 141).

The 19 maps in figs. 132 to 150 are constructed from records obtained in the oak-hickory woodlots at the Rose Lake Wildlife Experiment Station. The two maps in figs. 151 and 152 are from the scrub oak squirrel study woods at the Swan Creek experiment station.

RANGE RECORDS FOR SQ. 15133 ♂

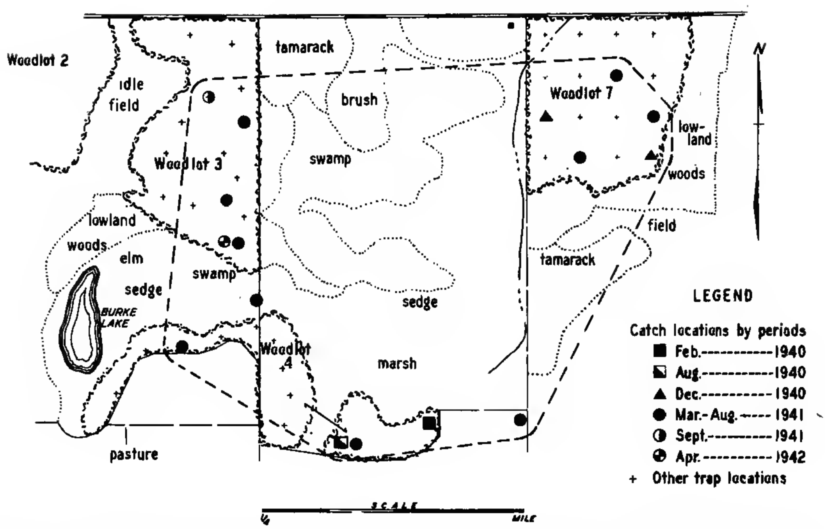


Fig. 132. This squirrel, an adult male in breeding condition when first captured, was taken 16 times between February 17, 1940 and April 3, 1942. Its testes declined in size in the summer of 1940 and again in 1941 after it bred early in the year. It moved about frequently between woodlots. First taken in woodlot 4 in February, it was in 7 in the following December where it was found again in March (1941). In April of that year it was back in woodlot 4 on the 3rd and in 7 again on the 17th. On May 2 and June 17 it was in 4, and in woodlot 3 on June 25 and 27. On August 24 it was in a fencerow trap east of woodlot 4 and then back in woodlot 3 on September 26. It was last handled there on April 3, 1942.

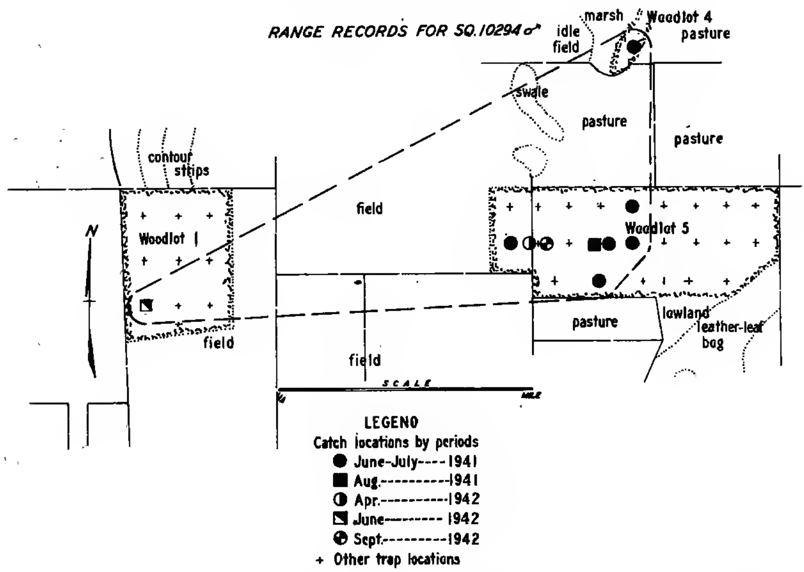


Fig. 133. This animal probably was a yearling when caught in woodlot 5 on June 19, 1941; that is, it was born in spring or early summer 1940. It was caught 11 times up to September 13, 1942. The first 4 catches were in woodlot 5, and on July 9 it was ⅛ mile north in the southern tip of the woods border beside Burke Lake. In August it was back in woodlot 5 where it was again taken in the following April. On June 26, 1942 this squirrel had moved more than ¼ mile west to woodlot 1 and was back in number 5 when last caught in September. It was in breeding condition in June of both years but evidently not earlier.

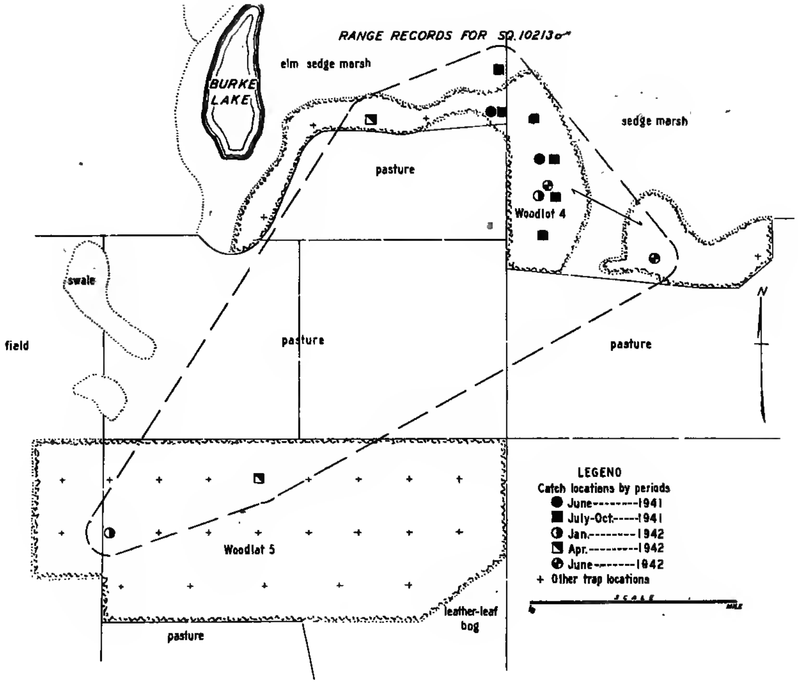


Fig. 134. Squirrel 10213 was an adult going out of breeding condition when first captured on June 16, 1941. It was caught a total of 18 times. It was handled 12 times in woodlot 4 up to October 7, and on the following, January 22, (1942) it was in woodlot 5. On the 29th of that month it was back in woodlot 4. On the 7th of April it was retaken in woodlot 5 and then in 4 again on the 11th, where it was last seen on June 29.

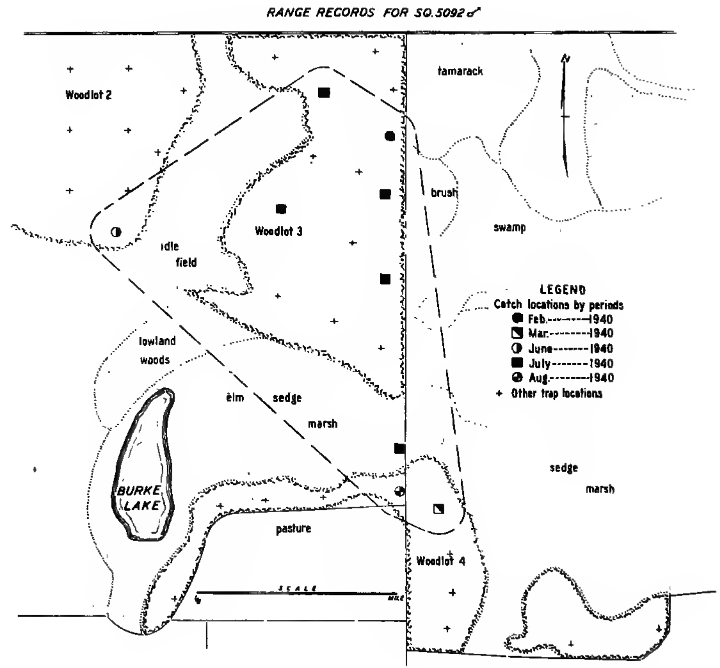


Fig. 135. This animal moved about between three woodlots from February to August 1940. It was taken 9 times and after breeding early in the year was found to be sexually quiescent from June on.

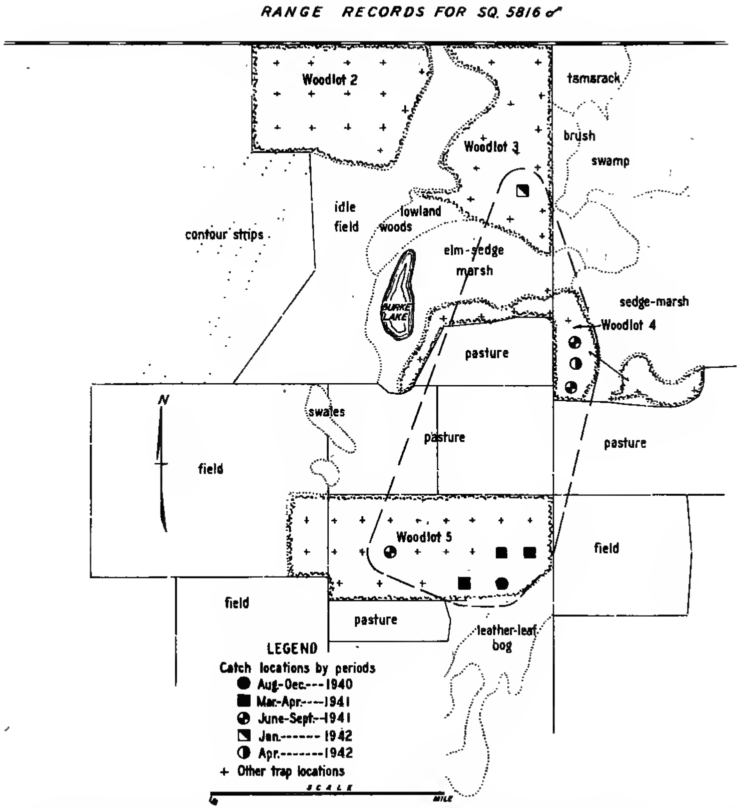


Fig. 136. This squirrel was taken 10 times, first in August 1940 and last in April 1942. It was in woods 5 until June 1941 according to the record. In January 1942 it was in woodlot 3 and in April in number 4. It seems to have bred in late spring both years. It was not in breeding condition early in the year or late in the summer.

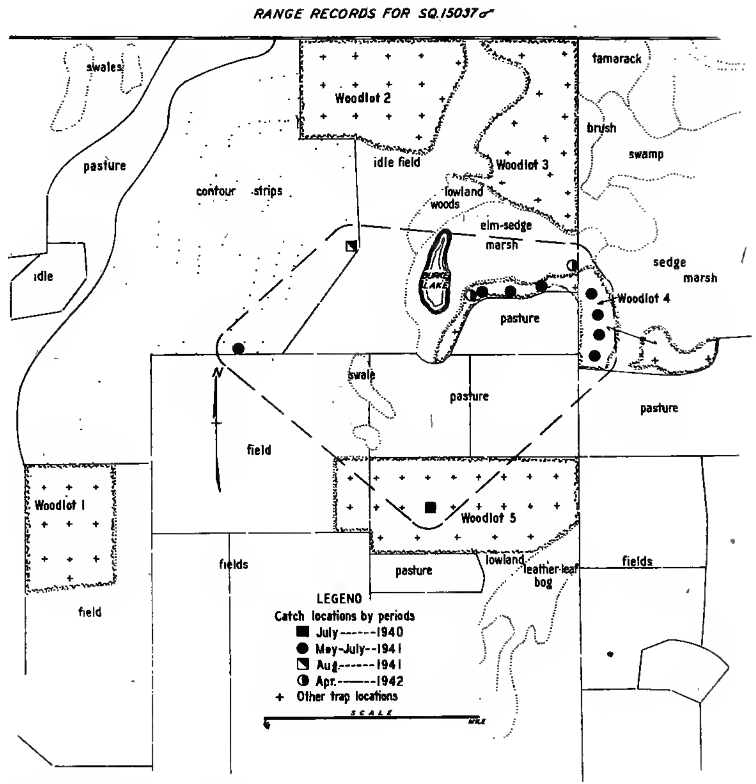
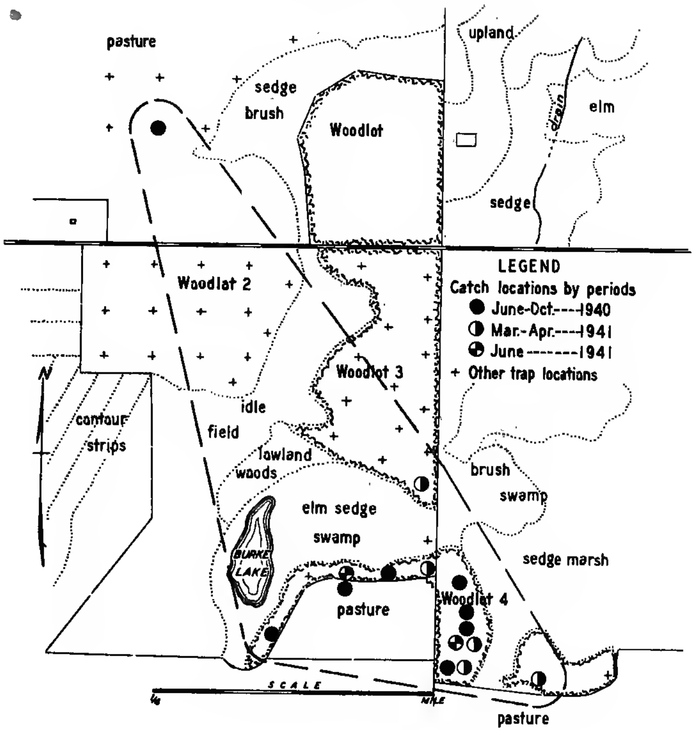


Fig. 137. This animal was taken 14 times—first in woodlot 5 on July 1, 1940. It was not seen again until May 7, 1941 when it was caught in woodlot 4. It repeated 7 times in that woods until July 11. On the 23rd of that month it appeared in a trap along a brushy fencerow a quarter of a mile west of the woods, and on August 4 it was 300 yards northeast in a trap beside a brushpile. In the following April it was back in woodlot 4 again. That woods evidently was its habitual "home," but the animal took at least one excursion lasting for at least a period of days and extending nearly half a mile away. This movement came in late July when it was sexually inactive.

RANGE RECORDS FOR SQ. 5383♀



RANGE RECORDS FOR SQ.10296♂

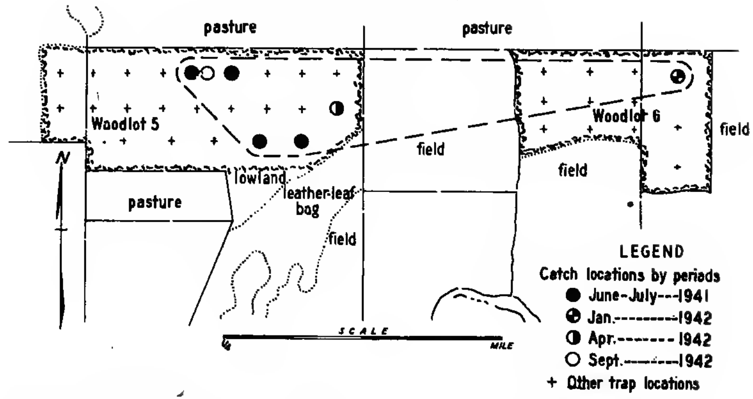


Fig. 138. This record of an adult female covers one year. The animal probably was a summer juvenile of 1939 and was first taken in June 1940. It bore its first litter in the summer of 1940 and another late in the winter following. It was fairly local in its movements around woodlat 4 except for one known excursion approximately three-quarters of a mile north. It was caught 16 times.

Fig. 139. This squirrel probably was reared in woodlot 5, as it was taken there as a 13-ounce juvenile in June 1941. It was recaptured there 3 more times up to August 3 and was not seen again until January 17, 1942 when it was caught in woodlot 6 about three-eighths of a mile to the east. On April 1 it was back in woodlot 5. It was caught a total of 9 times. This animal evidently lived in the same woodlot where it was born but took at least one trip to a neighboring woods. It came into breeding condition first in the spring of 1942.

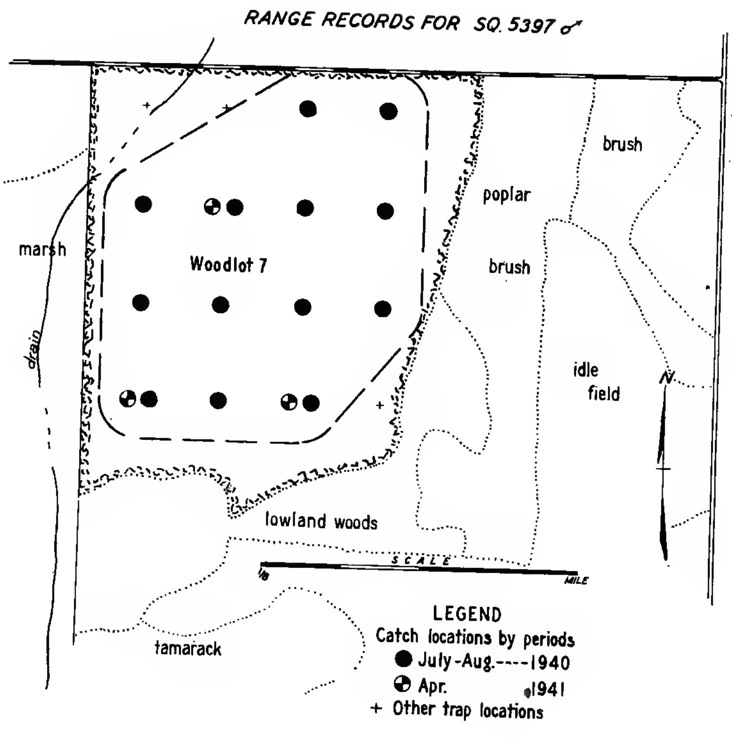


Fig. 140. Squirrel 5397 was a spring juvenile of 1940 and was taken first in July of that year. It was caught 36 times in woodlot 7 up to April 23, 1941. It was first in breeding condition early in that year. This animal was exceptionally local in its habits.

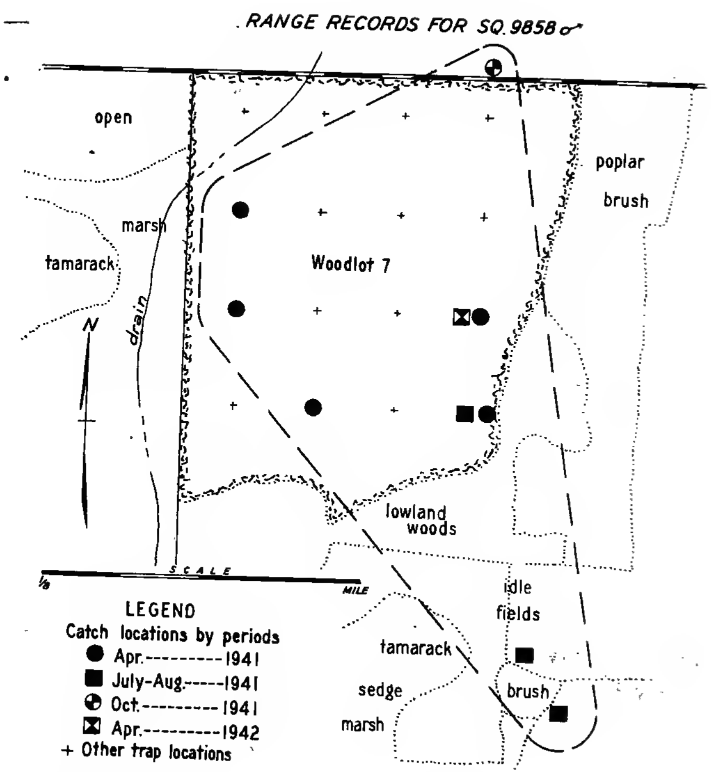


Fig. 141. An adult male, this animal was in full breeding condition when first taken on April 19, 1941. It was also in condition to breed a year later. It was taken 10 times in all and evidently spent most of its time in woodlot 7.

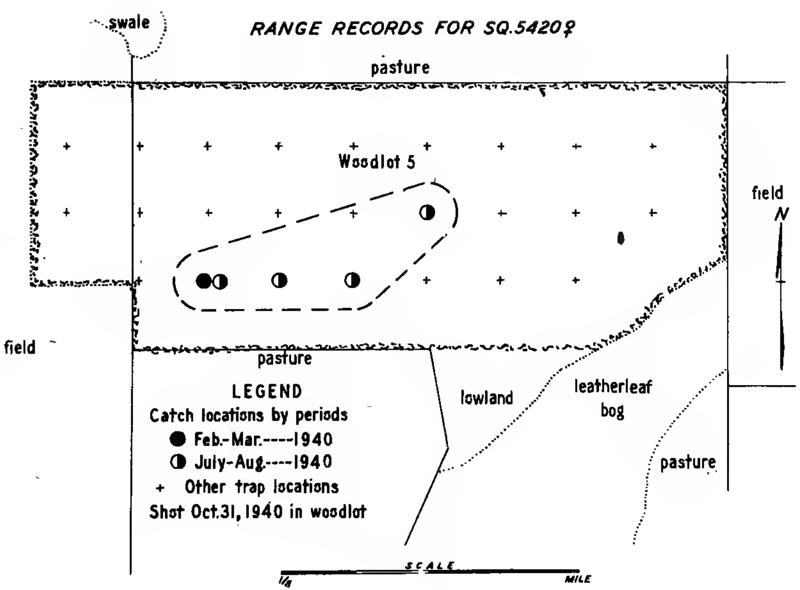


Fig. 142. This adult female bore two litters in woodlot 5 in 1940. It was first taken in February and last (shot) on October 31. It was captured 9 times, and its known range was entirely within the woodlot.

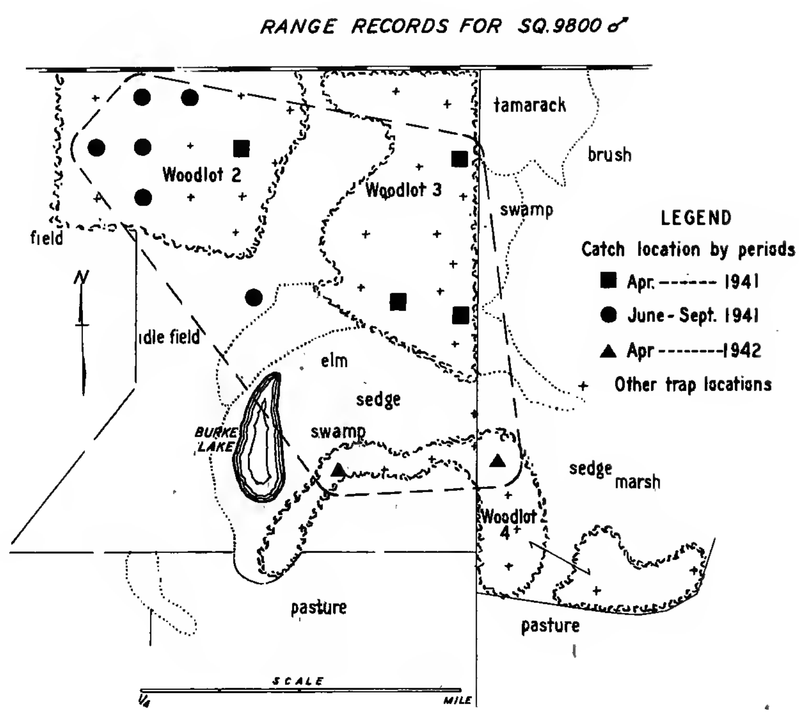


Fig. 143. Squirrel 9800 probably was a late spring juvenile of 1940. It was first captured on March 14, 1941 in a woodlot three-fourths of a mile northwest of the range here shown. Subsequent records are given on the map. The animal was found in woodlots 2 and 3 most of the time through September 1941, and in April 1942 was twice taken in woodlot 4. It seems to have moved about considerably, remaining in one spot for a time and then moving on to another.

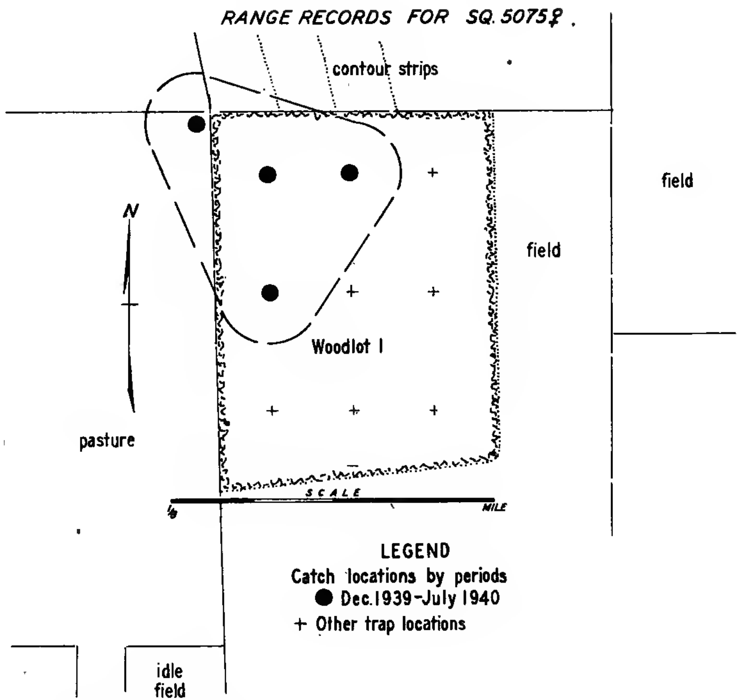


Fig. 144. This female probably was a 1939 spring juvenile. It was first taken in December of that year in woodlot 1 and was subsequently caught 4 more times in the same vicinity. On May 7, 1940 it was taken to the laboratory for examination and escaped half a mile south of the woodlot, where it was found again on June 27. This squirrel was last handled at Rose Lake on August 16, 1940. In the following hunting season it was shot in Section 19, Bennington Township, Shiawassee County. It had traveled approximately 10 miles in the 2-months-plus period. It bore a spring litter in 1940 but had no summer young.

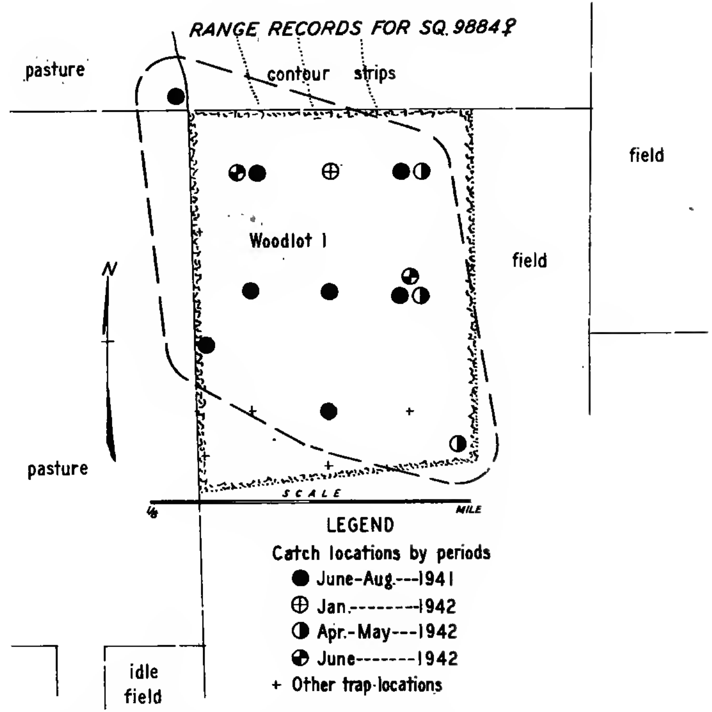


Fig. 145. This squirrel was first caught as an 11-ounce juvenile in woodlot 1 on June 18, 1941. It was recorded in or near that woods 7 more times through August 2 (weight 13 oz.). On the following January 17 it was retaken in the woods and found to be in full breeding condition. It bore a litter and was lactating when captured on April 1 and again on April 17. The animal evidently was raised and bred in the same woods. It was caught there 13 times.

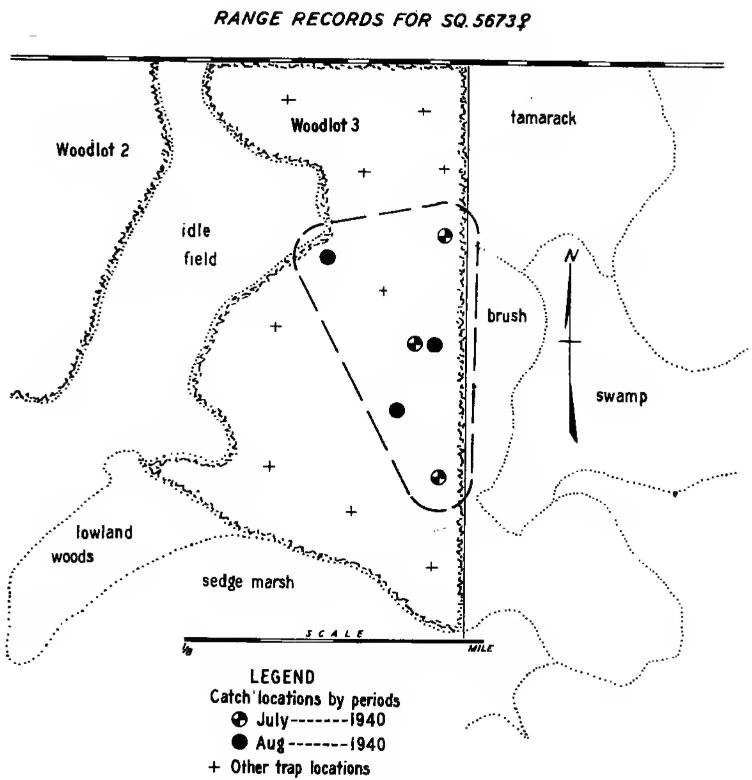


Fig. 146. The known range of a juvenile female during the month after it left the nest. It was caught first on July 22, 1940 weighing 8.5 ounces. On July 30 it was in a trap with a litter mate (fig. 147). It was captured 9 times up to August 12. Evidently it was quite local in habit during this time.

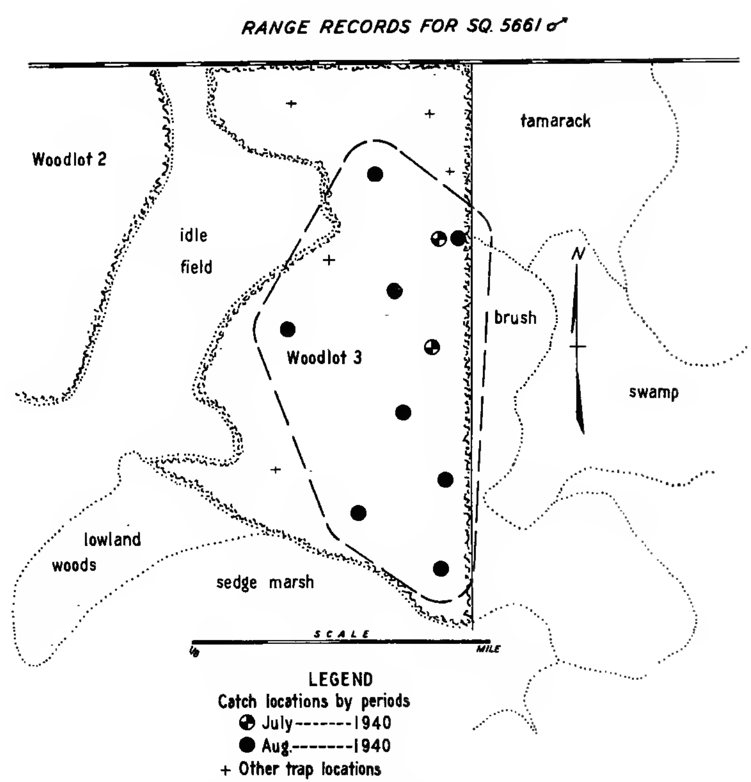


Fig. 147. Squirrel 5661 was a late spring or summer juvenile weighing 9.5 ounces when first taken on August 16, 1940. It was caught in the same trap with Sq. 5673, a litter mate, on July 30. Its range overlaps the range of the other animal whose history is shown in fig. 146. Both were restricted to woodlot 3 during this summer period and both probably left the area in late August or September, as neither was taken in intensive pre-hunting-season trapping.

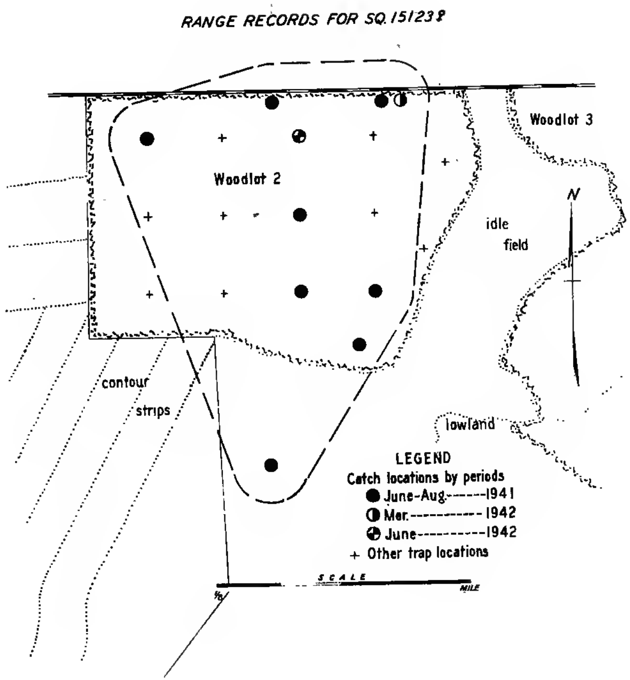


Fig. 148. This squirrel was caught 16 times. It was an adult and bore two litters in 1941 and another in the spring of 1942. A subsequent record since the map was made shows that the animal bore another litter in the summer of 1942.

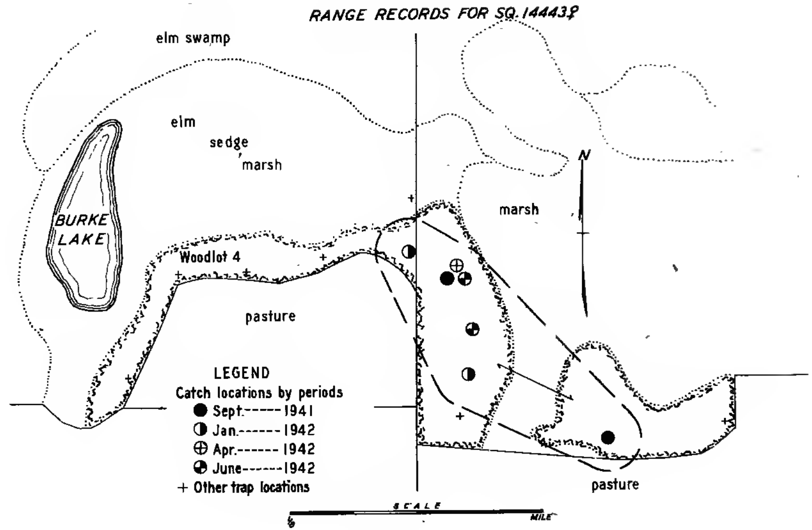


Fig. 149. This spring juvenile was first taken in woodlot 4 on September 12, 1941. It raised a litter in late winter and was still in the woods in the following June. It was captured 8 times.

RANGE RECORDS FOR SQ S603♀

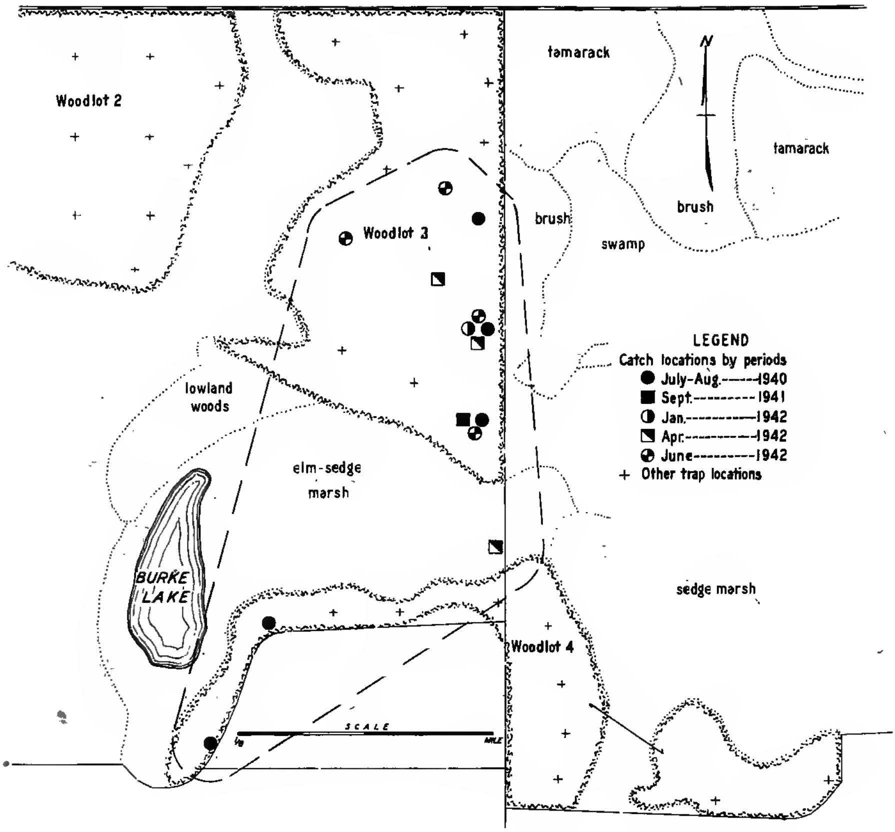


Fig. 150. The history of this animal runs from July 6, 1940 to February 2, 1943, during which period it was handled 22 times. It was an adult and evidently bred in late winter 1940. It bore another litter in the spring of 1941 but was not handled again that year. Early in 1942 it bred, and was pregnant for the second time in July. Information beyond June 1942 is not given on the map; but further records show that the animal escaped its third hunting season in 1942 and was pregnant for the fourth consecutive winter breeding period in February 1943.

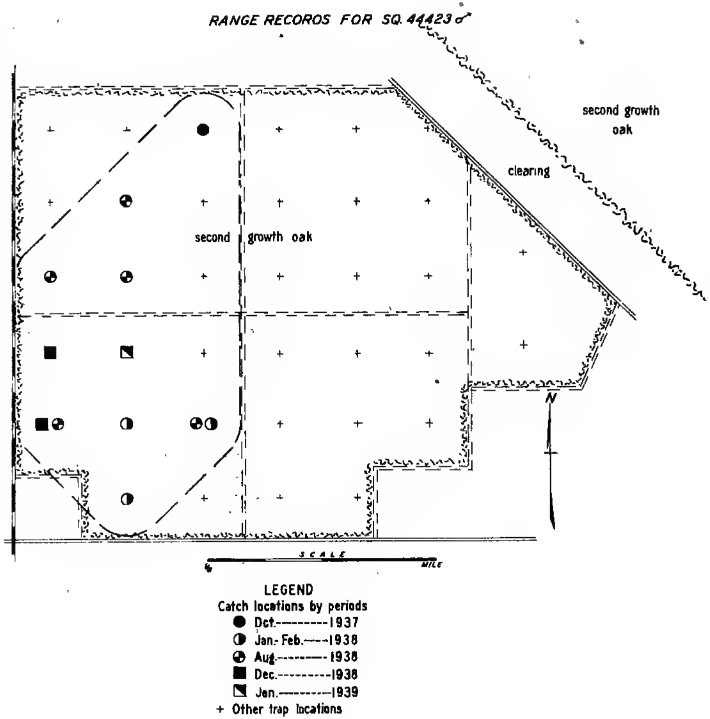


Fig. 151. Range record of an adult male squirrel in the 40-acre squirrel study woods at the Swan Creek experiment station. This animal was taken 19 times between October 31, 1937 and January 16, 1939. The area around the woods was not trapped and only the range within the plot is shown.

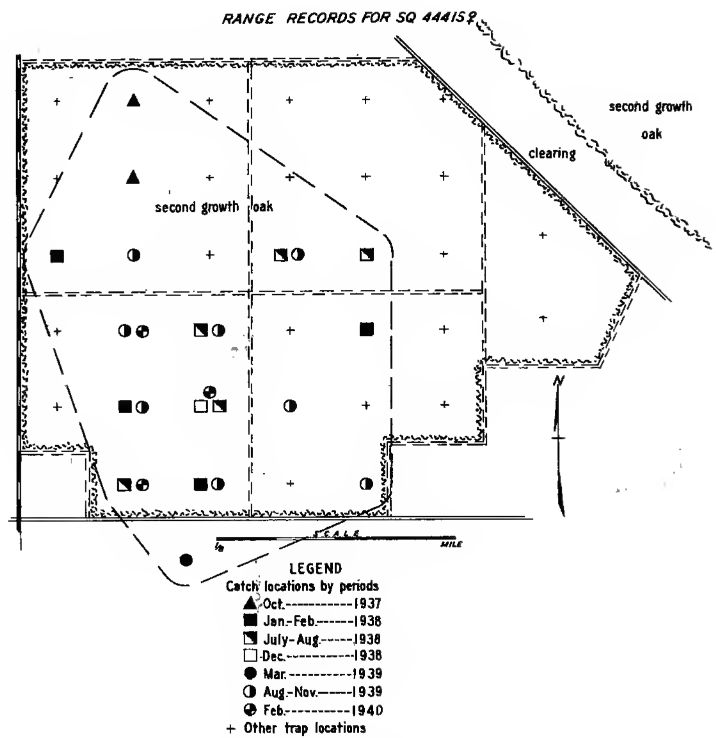


Fig. 152. Range of a female squirrel between October 8, 1937 and February 26, 1940. This animal probably was a spring juvenile of 1937. It bore one litter in 1938 and two in 1939.

APPENDIX E

Technical Names of Woody Plants Mentioned in the Text

Alder
    Smooth alder. *Alnus rugosa* (Ehrh.) Spreng.
    Speckled alder. *Alnus incana* (L.) Moench.

Ash
    Black ash. *Fraxinus nigra* L.
    White ash. *Fraxinus americana* L.

Aspen
    Largetooth aspen. *Populus grandidentata* Michx.
    Quaking aspen. *Populus tremuloides* Michx.

Basswood. *Tilia americana* L.

Beech
    American beech. *Fagus grandifolia* Ehrh.
    Blue beech, water beech (see ironwood).

Birch, yellow birch. *Betula lutea* Michx. f.

Bittersweet. *Celastrus scandens* L.

Bladdernut. *Staphylea trifolia* L.

Boxelder. *Acer negundo* L.

Butternut. (see walnut).

Cedar, northern white cedar. *Thuja occidentalis* L.

Cherry
    Black cherry. *Prunus serotina* Ehrh.
    Chokecherry. *Prunus virginiana* L.

Chestnut
    American chestnut. *Castanea dentata* (Marsh.) Borkh.
    Chinese chestnut. *Castanea mollissima* Bl.

Cottonwood. *Populus deltoides* Michx.

Cranberrybush, highbush cranberry. *Viburnum trilobum* Marsh.

Dogwood. *Cornus* (various species).

Elderberry
    American elderberry. *Sambucus canadensis* L.
    Scarlet elderberry. *Sambucus pubens* Michx.

Elm
    American elm. *Ulmus americana* L.
    Rock elm. *Ulmus racemosa* Thomas
    Slippery elm. *Ulmus fulva* Michx.

Fir, balsam fir. *Abies balsamea* L. Mill.

Grape
- Frost grape. *Vitis vulpina* L.
- Riverbank grape. *Vitis riparia* Michx.

Hackberry. *Celtis occidentalis* L.

Hawthorn. *Crataegus* spp.

Hazelnut. *Corylus americana* Walt.

Hemlock. *Tsuga candaensis* (L.) Carr.

Hickory
- Bigleaf shagbark hickory, kingnut hickory. *Carya laciniosa* (Michx. f.) Loud.
- Bitternut hickory. *Carya cordiformis* (Wang.) K. Koch.
- Pignut hickory. *Carya glabra* (Mill.) Sweet.
- Shagbark hickory. *Carya ovata* (Mill.) K. Koch.
- Small-fruited hickory. *Carya ovalis* (Wang.) Sarg.

Hop-hornbeam, ironwood. *Ostrya virginiana* (Mill.) K. Koch.

Ironwood, blue beech. *Carpinus caroliniana* Walt.

Maple
- Black maple, hard maple. *Acer nigrum* Michx. f.
- Hard maple, sugar maple. *Acer saccharum* Marsh.
- Red maple, soft maple. *Acer rubrum* L.
- Silver maple, soft maple. *Acer saccharinum* L.

Nannyberry. *Viburnum lentago* L.

Oak
- Black oak. *Quercus velutina* Lam.
- Bur oak. *Quercus macrocarpa* Michx.
- Chinquapin oak. *Quercus muhlenbergi* Englm.
- Jack oak. *Quercus ellipsoidalis* E. J. Hill.
- Red oak. *Quercus borealis maxima* (Marsh.) Ashe.
- Scarlet oak. *Quercus coccinea* Muench.
- Shumard red oak. *Quercus shumardi* Buckley.
- Swamp white oak. *Quercus bicolor* Willd.
- White oak. *Quercus alba* L.

Osage orange. *Maclura pomifera* (Raf.) Schneid.

Pine
- Jackpine. *Pinus banksiana* Lam.
- Red pine, Norway pine. *Pinus resinosa* Ait.
- White pine. *Pinus strobus* L.

Plum, american plum. *Prunus americana* Marsh.

Poplar (see aspen, cottonwood).

Sassafras. *Sassafras albidum* (Nutt.) Nees.

Serviceberry. *Amelanchier canadensis* (L.) Medic.

Spicebush. *Lindera benzoin* Blume

Spruce
- Black spruce. *Picea mariana* (Mill.) B. S. P.
- White spruce. *Picea glauca* Voss

Sumac
- Shining sumac. *Rhus copallina L.*
- Smooth sumac. *Rhus glabra* L.
- Staghorn sumac. *Rhus typhina* L.

Sycamore. *Platanus occidentalis* L.

Tamarack. *Larix laricina* (DuRoi) Koch.

Tulip tree. *Liriodendron tulipifera* L.

Virginia creeper. *Parthenocissus quinquefolia* (L.) Planch.

Walnut
- Black walnut. *Juglans nigra* L.
- White walnut, butternut. *Juglans cinerea* L.

Willow, black willow. *Salix nigra* Marsh.

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